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CONTENTS

PANCREATIC DIGESTION OF PLANT AND ANIMAL PROTEINS

R. M. BANERJEE AND N. B. DAS

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Received: November 24, 1958

Pulses constitute an important article of food in India, and considerable work has been done on the biological value of their protein contents (Basu *et al.*, 1935-36; Swaminathan, 1936-37; Esh and Som, 1952; Banerjee *et al.*, 1956). Considering its dietary importance, a study of the behaviour of pulse and animal proteins, when subjected to *in vitro* digestion by pancreatin, was undertaken and the results are presented here.

MATERIAL AND METHODS

Pulses used in this study were Gram NP53, *Mung* NP23, Lentil Hyb-1, *Rahar* NP15, *Urid* NP4 and Peas NP29. The pulses were dehusked and ground to pass through 40 mesh, cooked in steam for an hour, dried, and finally powdered.

Preparation of meat meal: Minced meat was treated with five volumes of ice-cold acetone, and again with three volumes of the same, filtered and dried in vacuum. The adhering fibre was separated by sieving the dried and powdered material.

In vitro digestion: The degree of hydrolysis of the protein was measured by formol titration. Aliquots of pancreatic digests and also of the controls were withdrawn at fixed intervals of time, neutral formalin (40 per cent) added to it, shaken and titrated with N/10 NaOH at *p*H 8·3 with the help of a Beckman Glass Electrode *p*H Meter (H_2).

The protein hydrolysates of the pulses, meatmeal and casein (Merck's preparation) were prepared by refluxing on an oil bath at about 125°C., one gram of the sample or sample containing one gram of protein, as the case may be, with 25 ml. of 6 N HCl for 24 hours, diluted and evaporated to remove HCl. It was filtered, washed and neutralised with NaOH and made up to 100 ml. The number of ml. of N/10 NaOH required for titration of 100 ml. of the hydrolysate at *p*H 8·3 was taken to be the maximum degree of hydrolysis for one gram of material or material containing one gram of protein.

Trichloroacetic acid precipitation experiments on pancreatic digests: Duplicate samples containing defatted pulses and meatmeal were digested with pancreatin and phosphate buffer at 37°C. for 24 hours and 48 hours respectively. After the incubation period, the digests were acidified with diluted HCl. In one set of experiments the digests were filtered through Whatman filter paper No. 42, washed with hot water and nitrogen estimated. To another set 10 ml. of 5 per cent trichloroacetic acid was added, shaken, filtered and washed with hot water containing 0·5 per cent trichloroacetic acid and nitrogen estimated.

RESULTS AND DISCUSSION

Preliminary digestion experiments were conducted to find out the activity of different commercial preparations of enzymes and pancreatin (U.S.P.) was found to be

satisfactory. It was, therefore, used throughout this study with sub-optimal quantity to permit digestion to proceed for several days.

Six pulses were digested with pancreatin for different periods and the results are given in Table I.

TABLE I. PANCREATIC DIGESTION OF PULSE PROTEINS*

Sample	Extent of hydrolysis per cent after			
	1 day	3 days	7 days	10 days
Gram	23·5	42·0	57·0	60·4
Mung	12·6	27·0	42·9	44·6
Lentil	25·8	39·4	51·5	53·8
Rahar	14·5	31·7	43·5	45·3
Urid	15·0	31·5	43·4	44·9
Peas	23·7	38·2	50·0	52·6

*6 gm. of pulse sample (cooked, dried and powdered) + 150 ml. of M/5 phosphate buffer (*p*H 8·3) + 300 mgm. of pancreatin incubated at 37° C. with 10 ml. toluene and shaken occasionally.

From Table I it appears that in 24 hours maximum hydrolysis occurred in lentil, peas and gram, lesser in *urid* and *rahar*, the least in *mung*. Subsequently, the rate of hydrolysis of gram becomes more pronounced than that of any other pulse, being highest in gram followed by lentil, peas, *rahar*, *urid*, and *mung*. The rate of hydrolysis of *rahar* and *urid* is about the same throughout the digestion period and that of *mung* is slightly less.

In view of the low *in vitro* digestibility of pulse proteins as observed herein, it was thought to be of interest to compare it with that of animal proteins. Pancreatic digestion was, therefore, carried out with meatmeal, casein, gram and lentil. The effect of supplementation with vitamin B_{12} on the digestion of pulse protein was not significant (Table II).

From Table II it appears that in 24 hour digestion, meatmeal had the highest value, closely followed by casein, and that of gram and lentil was appreciably less. But with the increase in digeston period, the rate of digestion in animal protein slowed down and that of pulse protein was accelerated so much so that in seven days the rate of hydrolysis of meatmeal and gram became of the same order. This suggested that in short-time digestion the rate of hydrolysis was much more pronounced in animal protein than in pulse protein. The supplementation with vitamin B_{12} did not have any significant effect on the digestion of the pulse proteins.

All the previous experiments were carried out on equal weight basis and it was thought expedient to repeat the experiments with samples containing equal quantity of protein. The percentages of digestion conducted on such basis did not differ from those cited earlier.

TABLE II. PANCREATIC DIGESTION OF ANIMAL AND PULSE PROTEINS*

Sample	Extent of hydrolysis per cent after				
	1 day	2 days	5 days	7 days	10 days
Meat meal	35·7	42·9	52·7	58·4	61·7
Casein	33·3	37·7	44·3	49·0	51·3
Gram	26·8	38·0	50·3	58·2	61·5
Gram+vitamin B_{12}	25·7	36·9	47·2	55·9	58·2
Lentil	27·3	36·4	46·3	52·5	54·6
Lentil+vitamin B_{12}	26·3	34·3	43·4	50·5	52·5

*3 gm. of sample+100 ml. of M/5 phosphate buffer (pH 8·3)+150 mgm. of pancreatin incubated at 37° C with 5 ml. of toluene and shaken occasionally. 10 microgram of vitamin B_{12} was used.

Bondi and Birk (1952) reported to have observed certain difference in the *in vitro* digestion of animal and plant protein feeds by trichloroacetic acid precipitation. This observation suggested the probability of formation of different intermediary products during the course of digestion of plant and animal proteins, and a similar study was made on meatmeal and different pulses.

TABLE III. INSOLUBLE NITROGEN IN THE PANCREATIC DIGESTS OF ANIMAL AND PULSE PROTEINS*

Sample	Total nitrogen (per cent)	After 24 hr. digestion (p.c. of total N)		After 48 hr. digestion (p.c. of total N)	
		Insoluble N	Insoluble+ precipitated N by adding trichloroacetic acid to pancreatic digest	Insoluble N	Insoluble + precipitated N by adding trichloroacetic acid to pancreatic digest
Meat meal	13·6	33·5	34·0	25·4	25·7
Gram	3·78	58·7	61·1	52·9	55·0
Mung	3·46	78·9	79·5	75·2	77·8
Lentil	4·18	51·2	51·7	44·3	46·2
Rahar	3·32	71·1	71·7	63·6	65·7
Urid	3·93	68·7	70·5	63·1	64·6
Peas	4·65	62·8	63·0	55·0	56·5

*Defatted samples containing 0·5 gm. of protein + 15 ml. of M/5 phosphate buffer (pH 8·3)+25 mgm. pancreatin incubated at 37° C with 1 ml. toluene.

There appears to be no significant difference in the figures either in the case of meatmeal or pulse protein in 24 and 48 hours pancreatic digests with and without precipitation with trichloroacetic acid under our experimental conditions.

SUMMARY

In vitro pancreatic digestion of pulse proteins in gram, *mung*, lentil, *rahar*, *urid* and peas has been compared with that of animal proteins in meatmeal and casein.

In 24 hours digestion meatmeal has the highest value, closely followed by casein while the digestion of the pulse proteins is considerably less. This suggests the superiority of animal proteins over plant proteins as far as their *in vitro* digestion is concerned.

With longer period the digestion of gram proteins approaches that of meatmeal. Among the pulses, gram, lentil and peas are more easily digested than *rahar*, *urid* and *mung*.

The supplementation with vitamin B_{12} has no influence on the *in vitro* digestion of pulse proteins and no significant difference exists in the insoluble nitrogen of the pancreatic digests of animal and pulse proteins even after precipitation with trichloroacetic acid.

ACKNOWLEDGEMENTS

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A STUDY ON THE QUALITY OF UNDERGROUND AND IRRIGATION WATER IN THE CHAMBAL COMMANDED AREA OF RAJASTHAN

II. BUNDI DISTRICT

N. R. TALATI[1] AND K. M. MEHTA[2]

Received : October 1, 1958

A knowledge of quality of underground waters and the depth of their occurrence has a great bearing on irrigation. Failures of irrigation at many places have been attributed to poor quality of underground waters and shallow water-table.

The Chambal commanded area includes Kotah and Bundi districts. The present work deals with the investigation of the quality of water of Bundi district which is situated on the left bank of Chambal river (Fig. 1). The Bundi and Mukandwara Range form the northern and western boundaries of the area and the river Chambal,

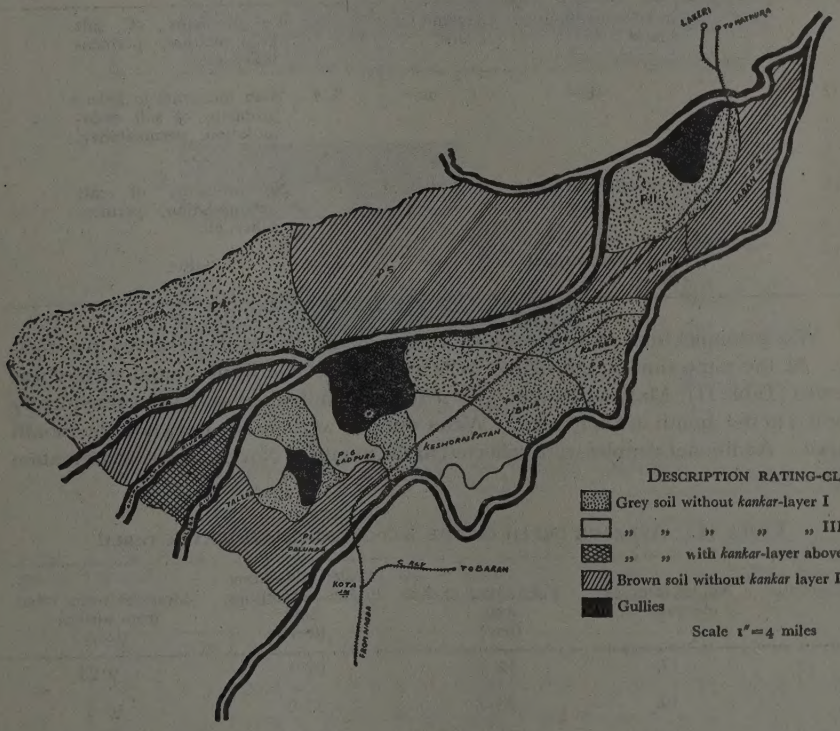

FIG. 1. SOIL TYPES OF BUNDI DISTRICT UNDER CHAMBAL COMMANDED AREA

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lies on the south-east. The climate is tropical with an average rainfall of about 31 inches. The rivers Mangli, Ghorapachar, Talera, Chambal and many seasonal *nallahs* and gullies constitute the main drainage of the area. The soils are of four classes, based on the colour of the surface soil, occurrence of *kankar* layer and its depth, and the extent of existing problems if any (Table I). Further, they are mostly grey and brown without a *kankar*-layer.

Most of the area which is well drained and free from salinity, alkalinity, water logging, etc., has been placed in rating class 1. The rating classes 3 and 4 belong mostly to low-lying area and have moderate to severe problems of drainage, salt accumulation, water logging, etc. Lands under the rating class 2 with slight to moderate problems do not occur in this district.

TABLE I. DATA ON SOILS OF BUNDI DISTRICT

Soil group	Description	Texture	Land rating class	Remarks on soils
I	Grey soils without *kankar* layer	Clay and Clay loam	1	No problems of salt accumulation, permeability, etc.
II	–do–	–do–	3, 4	With moderate to severe problems of salt accumulation, permeability, etc.
III	Grey soils with *kankar* layer about 4 ft.	–do–	1	No problems of salt accumulation, permeability, etc.
IV	Brown soils without *kankar* layer	–do–	1	–do–

Water samples from wells were collected during the course of soil survey investigation. At the same time depth of the wells and water table from ground surface was observed (Table II). Maximum water table reached in individual wells was subsequently recorded in the month of September. Water samples were mostly drawn in the month of April. Additional samples were collected in the month of November for confirmation of the results.

TABLE II. AVERAGE DEPTH OF THE WELLS AND THEIR WATER TABLE

Soil group	No. of samples observed	Total depth of the well (feet)	Water table from surface at sampling time (feet)	Monsoon water table from surface (feet)
I	17	44·2	16·0	9·23
II	19	43·7	20·0	16·8
III	17	34·8	18·1	12·1
IV	15	50·8	21·7	13·3

EXPERIMENTAL OBSERVATIONS

The results of analysis of water samples are given in Table III. The deviation in soluble salts, sodium percentage and residual alkalinity, sodium adsorption ratio, possible sodium percentage and sodium per cent present are given in Table IV. Fig. 2 shows the average distribution of salts in waters of each soil group.

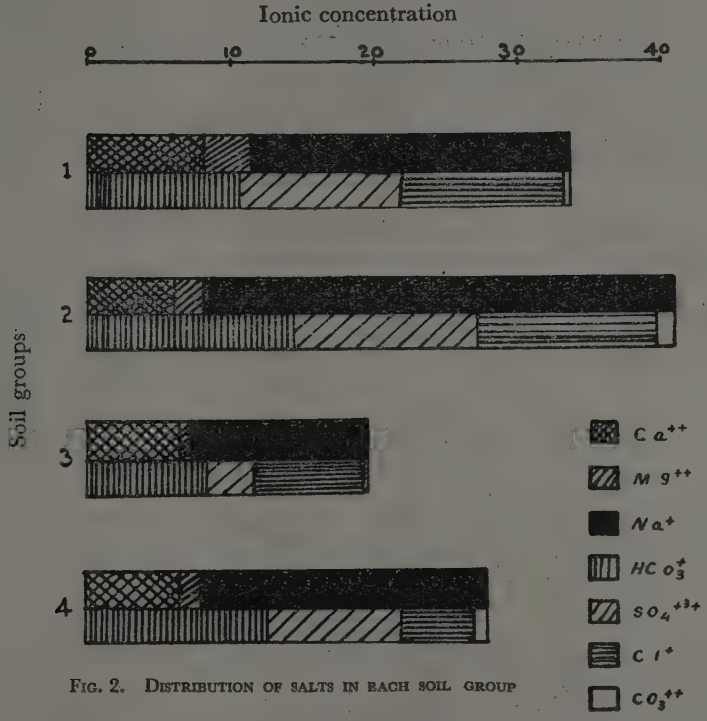

FIG. 2. DISTRIBUTION OF SALTS IN EACH SOIL GROUP

TABLE III. ANALYSIS OF WATER SAMPLES

Soil group	No. of samples examined	pH	Total salts in p.p.m.	Cations in e. p. m.			Anions in e. p. m.				Total ionic concentration in e. p. m.
				Calcium	Magnesium	Sodium	Carbonate	Bicarbonate	Sulphate	Chloride	
I	18	7·99	2098·0	8·21	3·55	21·94	0·43	10·89	11·23	11·15	33·7
II	19	8·3	2554·0	6·06	2·00	32·85	1·33	14·61	12·65	12·32	40·91
III	17	8·4	1178·0	6·75	0·56	12·34	0·1	8·27	3·38	7·90	19·65
IV	17	8·05	1774·0	6·38	1·87	19·70	1·0	12·66	9·42	4·87	27·95

In all the soil groups the water table at the time of sampling generally varied from 16 to 21·7 ft. from the ground surface and in monsoon period (September) from 9·23 to 16·8 ft. The salt content was generally high and varied 1178·0 p.p.m. to 2554.0 p.p.m. Soil reaction was alkaline, varying from 7·99 to 8·4. Generally, monovalent cations predominated the divalent cations. Carbonates were usually low in all waters. In Soil Groups I, II and IV, total salts were associated with high amounts of bicarbonate, sulphate and chloride ions, while the waters of Soil Group III predominantly contained bicarbonate ions. All the waters generally contained more than 60 per cent of sodium and more than 98 per cent of possible sodium, which was very high. Residual alkalinity was above the injurious limit in Soil Groups II and III. According to sodium-adsorption ratio, waters usually fell in C4S3, C4S4 and C3S2 Classes. This is based on the classification recommended by Thorne and Peterson (1954).

TABLE IV. FURTHER DATA ON ANALYSIS OF WATER SAMPLES

Soil Group	Total salts (P.P.M.)		Per cent sodium		Observed Na×100 total cations	Possible Na+100 Total (CO_3+ HCO_3)−	Residual alkalinity (CO_3+ HCO_3)−(Ca+Mg)	Sodium adsorption ratio Na / Ca+Mg	Water Quality
	Max.	Min.	Max.	Min.					
I	6,000·0	480·0	88·04	6·94	65·1	98·03	Nil	9·01	C4–S3
II	5,680·0	964·0	95·34	50·54	80·34	100·0	7·88	16·02	C4–S4
III	4,848·0	502·0	88·03	0·00	62·80	100·0	1·06	5·06	C3–S2
IV	7,162·0	354·0	93·24	0·00	700·49	100·0	5·41	9·70	C4–S3

DISCUSSION

Well water of Bundi district contained on the whole soluble salts between 1178·0 p.p.m. to 2554·0 p.p.m. with sodium per cent varying from 62·80 per cent to 80·34 per cent. According to Eaton (1950) such waters are generally unsuitable. The residual alkalinity in Soil Groups II and IV varied from 5·41 to 8·0 p.p.m. The residual alkalinity in Soil Groups I and III was, however, low. Waters with soluble salts less than 160·0 p.p.m. (C1) were most suitable; with 160·0 p.p.m. of total salts to 480·0 p.p.m. (C2) were suited for most plants; with 480·0 p.p.m. to 1440·0 p.p.m. (C3) good drainage was required; and above 1440·0 p.p.m. (C4) the waters were usually unsuitable. Depending upon the amount of total salts, the limit of sodium adsorption ratio for five classes of waters graphically represented by Fig. 3. On basis of this classification the waters usually fall in the high to medium-high salinity class (C4-S3). The waters of Soil Groups I and VI fall in C4-S3 class of Soil Group II in C4-S4 class and of Soil Group III in C3-S2 class.

In Soil Group I (grey soils without *kankar* layer) during monsoon period the water table was usually 9 ft. and the maximum fall 7 ft. Though the soils did not indicate

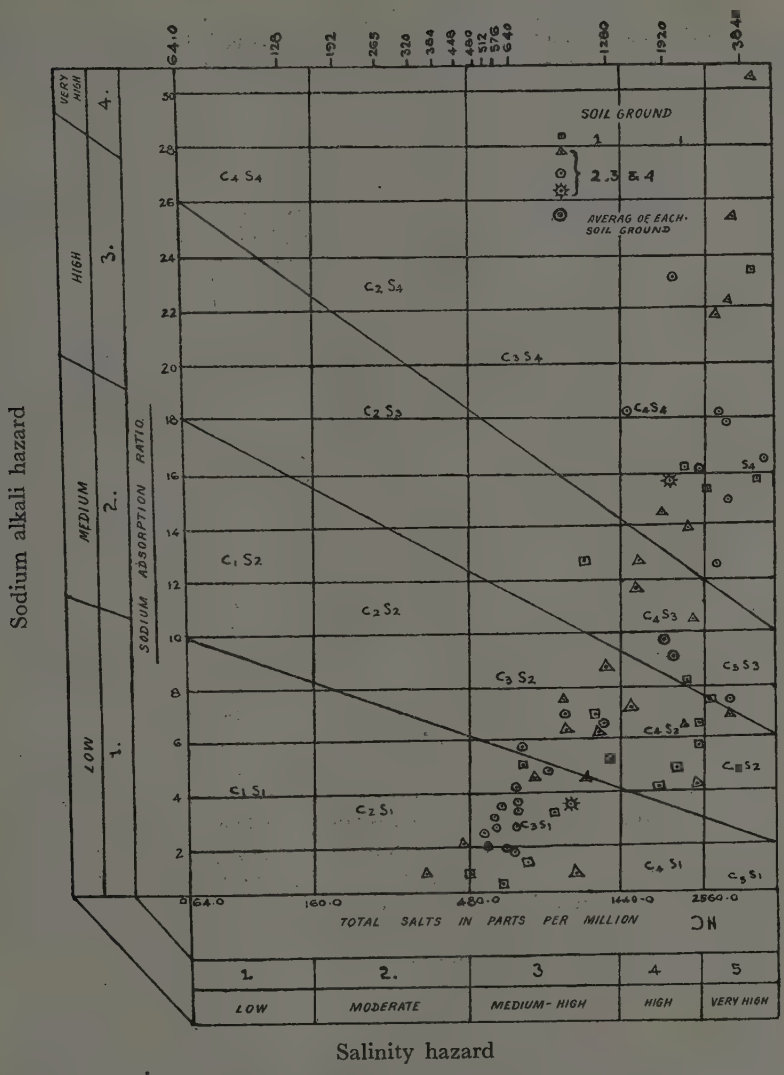

FIG. 3. SODIUM ABSORPTION RATIO FOR FIVE CLASSES OF WATER

salt accumulation and were fairly drained yet the high salinity and alkalinity of underground waters with the predominant presence of sulphate and chloride salts of sodium, left them open to speedier danger of sodiumisation, if proper management for keeping water table low was not practised.

Underground waters in soil group IV exhibited similar characteristic with the difference in the underground water table and high residual alkalinity. The underground water table during monsoon period of this group was 13 ft. and the maximum fluctuation was 8 ft. Though the water table was below ten inches to keep the soil safe, proper soil management practice cannot be ignored.

In Soil Group III with *kankar* layer above four inches, because of preponderance of precipitated calcium carbonate, the underground waters are rich in sodium and fall in class C3-S2. The water table during monsoon period was 12 ft. and the fluctuation was 6 ft. This Soil Group consisted of a very limited area and was situated between two rivers. This area is well drained and during floods underground water rises for a short period.

In Soil Group II the waters are usually highly saline and alkaline (C4-S4). The underground water table was 16·8 ft. with the fluctuation of only about 3 ft. The soils of this area already exhibited salt accumulation and poor permeability which was also evident from low fluctuation in water table. This soil group is open to severe danger of salinity, alkalinity and water logging problems. To meet the problems, intensive measures like proper drainage facilities, suitable cropping and judicious irrigation need be adopted.

Shaw (1952) reported that a water table below 6 ft. was a safe limit for soil management. Jenert (1933) showed that even temporary rise of water table adversely affects the crop growth and its yield. Israelsen (1950) stated that adequate crop production and perpetuation of soil fertility in irrigated areas required water table depth of 6 ft. or more. The critical depths of underground waters were found to depend upon the soil type, irrigation practices and the type of the crop growth. Since the monsoon water table of Bundi district is only little more than 10 ft., the maximum fluctuation is about 7 ft.; and the pellicular deficiency zone might extend even upto 10 ft.; care needs be taken to arrest its rise beyond ·10 ft.

It was observed that the underground waters of Bundi were comparatively more saline and alkaline than waters in Kotah district. The soils in Bundi seemed to be of recent alluvial deposits by virtue of their situation. Wilcox (1948) suggested that waters of newly deposited alluvium vary from doubtful to injurious quality, this was confirmed by Agarwal *et al.* (1956) for U.P. waters. This may account for high amounts to total dissolved salts and sodium absorption ratio for Bundi district.

Water from the Chambal river, is expected to be used for irrigating the lands and this is of good quality and needs no supplemental practices.

SUMMARY

Underground waters in Bundi district are generally of injurious nature and special care is necessary to check the rising of water table while irrigating this area and to prevent the development of salinity, alkalinity and water logging problems. Irrigation should be so practised that the water table is not allowed to rise beyond the critical depth. This may be possible by supplementing the irrigation with well waters. Wherever bad quality of underground water is encountered, recourse be taken by growing salt

resistant crops; proper drainage facilities, use of heavy amounts of organic manures, green manuring, etc. This will keep the salts trapped and reduce the rise in water table.

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RESULTS OF AGRONOMIC TRIALS ON *JOWAR* CONDUCTED AT INDORE (1947-1955)

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Received : September 27, 1955

Amongst millets such as *jowar* (*Sorghum vulgare*), *bajra* (*Pennisetum typhoides*), *ragi or mandua* (*Eleusine coracava*), *kondon* (*Paspalum scrobiculatum*) and *sawan* (*Panicum trusgalli*), the first two are chiefly cultivated in Madhya Bharat. *Jowar* and *bajra* occupy about 3·0 and 0·4 million acres respectively. The larger acreage (about 2·0 million acres) under *jowar* is estimated on the black cotton soil of the southern region known as Malwa Plateau while *bajra* is largely grown on the alluvial soils of the northern region of the State. Both these crops are grown under rainfed conditions and yield on an average 300 to 400 lb. of grain per acre. The yield can undoubtedly be increased to double or treble the present level by the use of improved varieties, manuring and timely and proper tillage operations. To ascertain the effects of these practices on the yield of *jowar* a series of factorial experiments have been conducted at the Institute of Plant Industry, Indore, and the results achieved thereof are reported in this article.

It is important to mention at the very beginning that these trials were carried out on two improved strains viz., I.P.I. 3 and I.P.I. 9 evolved at the Institute and are now under distribution in southern region of the State. I.P.I. 3 has an average grain yield capacity of 580 lb. per acre as against 350 lb. of the cultivators, has a lax earhead and white grain, while I.P.I. 9 has a lower grain yield (400 lb.) but a higher fodder yield than I.P.I. 3 and has a dense earhead and pearly grains. Both varieties are fairly resistant to striga.

It is also worthwhile to add that every trial reported in this article was laid out in a different field at the Institute farm in different seasons and that the treatments were also randomised independently every year. Although the experiments were repeated for a number of seasons but combined analysis was not possible due to the inconsistency in the number of replications and plot size from one season to another depending upon the dimensions of field available.

MANURING

Manuring method: As *jowar* is grown almost everywhere under rainfed conditions, its manuring aspect is to be considered in the light of the rainfall received during the crop period and such doses of the major nutrients nitrogen and phosphate are to be used which would give positive increases in the yields of both grain as well as *karbi* (fodder). Experiments were, therefore, started in 1947-48 with graded doses of 0, 20 and 40 lb. N and 0, 20, and 40 lb. P_2O_5 per acre in the form of groundnut cake and single superphosphate respectively and were applied singly and in combinations. The experiments were continued in the same manner for four seasons (1947-48 to

1950-51). The experiments were laid out in a simple randomised block design with 6 replications. The experimental plot six varied from 1/187 to 1/117th acre in different seasons. The yields of grain and *karbi* in lb. per acre for the four seasons are given in Table I.

It will be seen from the results in Table 1 that the yields of both grain and *karbi* were significantly higher with the application of 20 and 40 lb. N per acre than control except in 1948-49 in the grain yield and that yields with the higher dose of 40 lb. N did not differ significantly from 20 lb. N except in 1949-50. It means that the rate of response is of higher magnitude with 20 lb. N as compared to that of 40 lb. N. Hence considering the overall average effects of the four seasons 20 lb. N per acre seems to be better dose for *jowar* than the dose of 40 lb. under the local conditions.

With regard to the application of superphosphate, it did not give significantly higher yields than control, although indications are there to show slight beneficial effects of 20 lb. P_2O_5 per acre. Also there was no interaction between the levels of nitrogen and phosphate.

As the use of groundnut cake is prohibitive for manurial purposes due to its great value as a cattle-feed and higher cost per lb. of nitrogen as compared to ammonium sulphate, the trial was modified to study the effect of ammonium sulphate and superphosphate at 20 lb. N and 20 lb. P_2O_5 per acre respectively, singly and in combinations and with and without a basal dressing of farm compost applied two weeks before sowing at the rate of five cart loads per acre (equivalent to 40 lb. N per acre). Ammonium sulphate was broadcast at the time of sowing while superphosphate was drilled in the furrows a week before sowing. The experiment was laid out in a simple randomised block design. The number of replications and experimental plot size varied from 4 to 6 and 1/156th to 1/144th acre respectively in different seasons. The results obtained in the individual seasons and their analyses of variance are given in Table II(a) and II(b) respectively. In Table II(c) are shown the response of grain and *karbi* yields for the three main effects in individual seasons along with their standard errors.

A perusal of the analyses of the variance (Table IIb) will show that the grain yield of *jowar* did not increase significantly with the application of basal dressing (farm compost) or superphosphate in any of the seasons while with the application of ammonium sulphate a significant increase in the yield of grain was obtained in two out of three seasons. The yield of *jowar karbi* was also significantly increased with the application of ammonium sulphate in the first two seasons (1952-53 and 1953-54) while the application of farm compost failed to give significant increase in the yield. The application of superphosphate generally increased the *karbi* out-turn but the increase was found to be significant in one season (1953-54) only. The comparison of the effect of individual factor, namely basal dressing (farm compost), ammonium sulphate and superphosphate on the grain and *karbi* yields of *jowar* for three seasons is shown in Table II(c).

The economics for different factors singly and in combinations has also shown that the application of nitrogen (ammonium sulphate) gives the highest net money returns (Table III).

Table I. Yield in lb. per acre

Years	N×P	Grain						N×P	*Karbi*					
		0	20	40	Mean	S.E.	C.D.		0	20	40	Mean	S.E.	C.D.
1947–48	0	408	720	782	637	±42	Not sig.	0	2025	3921	4979	3651	±249	Not sig.
	20	600	802	898	767			20	2645	5010	5104	4253		
	40	523	830	802	718			40	2676	5134	5353	4388		
	Mean	510	784	827				Mean	2458	4689	5145			
	S.E.	±42						S.E.	±249					
	C.D.	120						C.D.	712					
1948–49	0	286	666	513	488	±110	Not sig.	0	814	1843	1795	1484	±152	Not sig.
	20	362	778	714	618			20	1029	2130	1939	1619	1939	
	40	438	513	765	572			40	1125	1412	2082	1540		
	Mean	362	652	664				Mean	989	1795	1939			
	S.E.	±110						S.E.	±152					
	C.D.	Not sig.						C.D.	435					
1949–50	0	423	592	606	540	±31	Not sig.	0	4476	7186	8736	6797	±330	Not sig.
	20	488	646	757	630			20	5002	7779	0052	7611		
	40	358	453	811	540			40	4428	6343	9334	6702		
	Mean	423	564	724				Mean	4635	7101	9374			
	S.E.	±31						S.E.	±330					
	C.D.	95						C.D.	992					
1950–51	0	867	1056	..	962	±34	Not sig.	0	1556	2100	..	1828	±83	242
	20	856	978	..	917			20	1925	2451	..	2188		
	Mean	861	1017	..	..			Mean	1741	2275	..	..		
	S.E.	±34						S.E.	±83					
	C.D.	101						C.D.	242					

Doses	0	20	40	*Means for all seasons*	*Doses*	0	20	40
N	539	754	738		N	2456	3965	5486
P	657	733	610		P	3440	3918	4210

TABLE II(a). YIELD IN LB. PER ACRE

Year	NP	Grain				*Karbi*			
		0–0	20–0	0–20	20–20	0–0	20–0	0–20	20–20
1952–53	No basal dressing	901	975	913	886	3829	5217	3901	4906
	Basal dressing with farm compost	821	895	802	1037	3442	4092	3590	5456
	Mean	861	935	857	961	3635	4654	3745	5181
	Response for basal dressing	−80	−80	−111	−151	−387	−1125	−311	−550
	Response for fertilisers	..	+74	−4	+100	..	+1019	+110	+1546
1953–54	No basal dressing	456	1113	812	1019	2257	2804	2519	3074
	Basal dressing with farm compost	924	965	951	1327	2374	2412	2568	3813
	Mean	690	1039	881	1173	2315	2608	2543	3443
	Response for basal dressing	+468	−148	+139	+308	+117	−392	+49	+739
	Response for fertilizers	—	+349	+191	+483	..	+293	+288	+1128
1954–55	No basal dressing	581	612	561	712	5548	6169	6673	7178
	Basal dressing with farm compost	620	819	566	659	7178	6867	7294	6324
	Mean	600	715	563	685	6363	6518	6983	6751
	Response for basal dressing	+39	+207	+5	−53	+1630	+698	+621	−854
	Response for fertilizers	..	+115	−37	+85	..	+155	+620	+388

TABLE II(b). ANALYSIS OF VARIANCE

Sources of variation blocks	D.F.	Grain M.S.S.	Grain F	*Karbi* M.S.S.	*Karbi* F
1952–53	5	2953·13	7·8†	1110·88	
Treatments	7	430·92	1·139	168·23	1·78
Levels of N	1	1121·33	2·966	841·69	8·90†
Levels of P	1	12·00	..	50·02	..
N×P	1	44·09	..	50·02	..
Basal dressing vs. no basal dressing	1	154·08	..	31·69	..
N×B	1	647·56	1·784	0·02	..
P×B	1	408·34	1·080	99·19	1·04
N×P×B	1	602·52	1·593	105·02	1·11
Error	35	378·03	..	94·47	..
1953–54					
Blocks	3	1292·11	6·4*	14·86	1·13
Treatments	7	1140·17	5·7*	42·81	3·26*
Levels of N	1	4209·03	21·17†	116·28	8·86†
Levels of P	1	357·28	1·79	94·53	7·12*
N×P	1	299·03	1·50	30·03	2·28
Basal dressing vs. no basal dressing	1	750·78	3·77	5·28	..
N×B	1	16·63	..	0·78	..
P×B	1	1417·78	7·13*	22·78	1·74
N×P×B	1	930·19	4·67*	30·04	2·28
Error	21	198·81	..	13·12	..
1954–55					
Blocks	3	371·78	..	155·58	1·47
Treatments	7	325·67	1·20	61·00	..
Levels of N	1	1188·28	4·40*	0·50	..
Levels of P	1	94·53	..	60·50	..
N×P	1	205·03	..	91·12	..
Basal dressing vs. no basal dressing	1	0·78	..	12·50	..
N×B	1	63·28	..	120·13	1·13
P×B	1	457·53	1·69	136·13	1·28
N×P×B	1	270·29	1·00	6·12	..
Error	21	269·79	..	105.89	..

*Significance at 5 per cent. †Significance at 1 per cent.

Seed rate cum *manuring*

Studies on the effects of seed rates and manuring were carried out for three consecutive seasons (1947-48 to 1949-50) to find out the optimum seed rate of *jowar* with and without the application of 20 lb. N per acre in the form of ammonium sulphate or groundnut cake. The seed rates of 5, 10, 15, 20 and 25 lb. per acre without thinning were compared with the normal seed-rate of 10 lb. with thinning operations in all the seasons.

The trial was laid out in a simple randomised block design with five to six replications. The experimental plot size also varied from 1/113th to 1/57th acre. The results are presented in Table III and are discussed below.

Since the interaction between seed rates and manuring was not significant in any of the seasons for both grain and *karbi* yield, the effects of the individual factor on the yield are dealt herewith. From the means of grain and *karbi* yield, it will be

TABLE II(c). TREATMENTS AND THE YIELDS PER ACRE

Treatments	Grain yield in lb. per acre				*Karbi* yield in lb. per acre			
	52–53	53–54	54–55	Mean	52–53	53–54	54–55	Mean
No basal dressing	920	947	616	828	4462	2661	6405	4509
Basal dressing with farm compost at 40 lb. N/acre	888	1042	665	865	4171	2786	6928	4628
S.E.	±35	±34	±40		±284	±140	±400	
C.D. at 5 per cent	Not sig.	Not sig.	Not sig.		Not sig.	Not sig.	Not sig.	
No ammonium sulphate	860	883	581	775	3715	2428	6686	4276
Am. sulphate at 20 lb. N per acre	947	1106	700	918	4919	3019	6648	4862
S.E.	±35	±34	±40		±284	±140	±400	
C.D. at 5 per cent	Not sig.	100	177		804	411	Not sig.	
No superphosphate	899	962	657	839	4222	2459	6453	4378
Superphosphate at 20 lb. P_2O_5 per acre	908	1027	624	853	4464	2988	6881	4477
S.E.	±35	±34	±40		±284	±140	±400	
C.D. at 5 per cent	Not sig.	Not sig.	Not sig.		Not sig.	411	Not sig.	

observed that the application of nitrogen increased the out-turn of grain as well as *karbi*, but the increase over 'no manure' was significant only in one season for grain and in all the three seasons for *karbi*. With regard to the seed rates it was found that the grain yield, when compared to the control, did not increase significantly with the higher seed rates unlike *karbi* weights. It can, therefore, be concluded that a seed rate of 10 lb. per acre is the optimum from the point of view of both grain and *karbi* yields and where thinning operation, too, need not be done except removing the plants at crowded spots. Also 20 lb. N per acre may be applied to get higher returns.

Sowing date cum *manuring*

Jowar is generally sown in June or July after a precipitation of about 3 to 4 in. of rains. The rainfal in this region usually commences with light showers in the second week of June and the quantity enough for sowing *jowar* is received by the end of June or first week of July (Appendix A). In order to find out the differences in the yield of *jowar* obtained by drilling the seeds in dry soil before the advent of drains and at the normal time after the onset of monsoon, a trial was laid out in the year 1952-53 in simple randomised block design with 4 replications and 1/113th acre plot size. In addition to sowing times, manuring with ammonium sulphate applied at 5, 10, 15 and 20 lb. N per acre at the time of sowing and varieties I.P.I. 3

TABLE III. ECONOMICS OF MANURING

Treatments	Average grain Yield lb. per acre	Average *karbi* yield lb. per acre	Extra grain yield over control lb. per acre	Extra *karbi* yield over control lb. per acre	Value of extra grain Rs.	Value of extra *Karbi* Rs.	Total Rs.	Cost of manure or manures Rs.	Profit Rs.
No manure (control)	646	3878	..	..	..	..	..	..	..
Farm compost at 40 lb. N per acre	788	4365	142	487	15-8-6	10-2-4	25-10-10	15-0-0	10-10-10
Amm. sulphate at 20 lb. N per acre	900	4730	254	852	27-12-6	17-12-0	45-8-6	12-15-5	29-12-1
Farm compost at 40 lb. N per acre plus amm. sulph. at 20 lb. N per acre	893	4457	247	579	27-0-3	12-1-0	39-1-3	30-12-5	8-4-10
Superphosphate at 20 lb. P_2O_5 acre	762	4368	116	490	12-11-3	10-3-4	22-14-4	11-3-10	11-10-6
Superphosphate at 20 lb. P_2O_5 per acre plus farm compost at 40 lb. N per acre	773	4484	127	606	13-14-3	12-10-0	26-8-3	26-3-10	0-4-5
Amm. sulphate at 20 lb. N per acre plus superphosphate at 20 lb. P_2O_5 per acre	872	5053	226	1175	24-11-6	24-7-8	49-3-2	27-0-3	22-2-11
Amm. sulphate at 20 lb. N per acre plus superphosphate at 20 lb. P_2O_5 per acre plus Farm compost at 40 N per acre	1008	5198	362	1320	39-9-6	27-8-0	67-1-6	42-0-3	25-1-3

Prices: Amm. sulphate (20 per cent.) N at Rs. 12-15-0 per *maund* (82 lb.).
Farm compost (0.9 per cent.) N at Rs. 3-0-0 cartload (about 10 *maunds*)
Single superphosphate (17 per cent.) P_2O_5 at Rs. 7-13-4 per *maund*.
Jowar grain at Rs. 9-0-0 per *maund*.
Karbi (*jowar*) at Rs. 1-11-4 per *maund*.

TABLE IV. GRAIN YIELD IN LB. PER ACRE

Seed rate N	1947–48					1948–49					1949–50					Mean for all seasons		Over-all mean
	0	20	Mean	S.E.	C.D.	0	20	Mean	S.E.	C.D.	0	20	Mean	S.E.	C.D.	0	20	
1. Control 10 lb. (Thinned)	670	985	827	±78	222	612	585	598	±42	123	497	543	520	±24	Not sig.	593	704	648
2. 5 „ (Unthinned)	710	640	675			403	601	502			490	574	532			534	605	570
3. 10 „ „	997	843	920			544	620	582			495	541	518			679	668	673
4. 15 „ „	740	1165	952			455	627	541			470	466	468			555	753	654
5. 20 „ „	943	975	959			430	532	481			396	389	392			590	632	611
6. 25 „ „	530	607	568			378	428	403			260	423	341			389	486	437
Mean	765	869				470	565				435	489				560	641	
S.E.	±44				S.E.	±24				S.E.	±41							
C.D.	Not sig.				C.D.	68				C.D.	Not sig.							
Karbi yield in lb. per acre																		
1. Control 10 lb. (Thinned)	3890	6224	5057	±547	1554	3009	3510	3259	±203	578	3470	4718	3894	±290	Not sig.	3456	4817	4136
2. 5 „ (Unthinned)	4765	6166	5465			2334	3631	2982			3734	3602	3668			3611	4466	4038
3. 10 „ „	4473	8947	6710			3147	4651	3899			3790	4658	4224			3803	6085	4944
4. 15 „ „	4960	7818	6389			3856	4945	4400			4243	4507	4375			4353	5757	5055
5. 20 „ „	6224	9141	7682			3303	4409	3856			4130	4790	4460			4552	6113	5332
6. 25 „ „	4649	8072	6360			3355	5015	4185			4413	5167	4790			4139	6085	5112
Mean	4827	7895				3167	4360				963	4507				3986	5587	
S.E.	±315				S.E.	±119				S.E.	±167							
C.D.	1199				C.D.	237				C.D.	482							

TABLE V(a). GRAIN

Levels of nitrogen	Pre-monsoon sowing		Normal sowing		*Mean*		Overall mean for levels of N
	I.P.I. 3 :	I.P.I. 9	I.P.I. 3 :	I.P.I. 9	I.P.I. 3 :	I.P.I. 9	
0	991	879	874	780	932	829	880 S.E.±38
5	953	706	902	812	927	759	843 C.D. at 5 per cent. Not sig.
10	1157	904	920	745	1038	824	931
15	1036	923	944	798	990	860	925
20	1202	918	897	891	1049	904	976
Mean	1068	866	907	805	987	835	
Mean for sowing date	967		856		S.E.		±24
					C.D. at 1 per cent		92

S.E. ±24
C.D. at 1 per cent 92

KARBI

Levels of nitrogen	Pre-monsoon sowing		Normal sowing		Mean		Overall mean for levels of N
	I.P.I. 3 :	I.P.I. 9	I.P.I. 3 :	I.P.I. 9	I.P.I. 3 :	I.P.I. 9	
0	3679	4047	3311	4075	3495	4061	3778 S.E.±220
5	3877	5292	2995	3962	3436	4627	4031 C.D. at 5 per cent. Not sig.
10	5291	4698	3877	3849	4584	4273	4428
15	3226	4585	4075	4380	3650	4482	4066
20	3764	5179	3622	4330	3693	4754	4223
Mean	3967	4760	3576	4119	3772	4439	
Mean for sowing date	4363		3847		S.E.±137 C.D. at 1 per cent 514		

S.E.±137
C.D. at 1 per cent 514

and I.P.I. 9 were also included to study if there is any interaction between these factors. Pre-monsoon and normal sowings were done on the 10th and 26th June respectively (4·75 inches rainfall between the two dates). The yields in lb. per acre are given in Table V(a).

Table V(a) shows that pre-monsoon sowing gave significantly higher grain and *karbi* yields than that of the normal sown crop. In grain yield I.P.I. 3 proved significantly superior to I.P.I. 9 while the reverse was the case with *karbi* out-turn. Although the application of nitrogen increased the yields but it was statistically nonsignificant; interaction between the treatments was also not significant.

TABLE V(b). LEVELS OF NITROGEN

Sowing time	0	10	20	30	Mean	
Grain						
Pre-monsoon sowing	783	898	813	972	868	S.E.±45
Normal sowing	798	751	921	888	839	C.D. at 5 per cent. Not sig.
Mean	790	829	867	930		
S.E. ±70						
C.D. at 5 per cent. Not sig.						
Karbi						
Pre-monsoon sowing	1904	2355	1970	2503	2203	S.E.±202
Normal sowing	2488	3140	2932	2621	2795	C.D. at 5 per cent. Not sig.
Mean	2196	2747	2451	2562		
S.E. ±350,						
C.D. at 5 per cent. Not sig.						

During 1953-54 pre-monsoon sowing was done on the 14th June and normal sowing on the 3rd July after receiving 2·67 in. rainfall. Ammonium sulphate was applied at 10, 20 and 30 lb. N per acre. The treatments were randomised in a split plot design with sowing dates in the main plots and doses of ammonium sulphate in the sub-plots. There were four replications with 1/59th acre experimental plot size. The yields in lb. per acre are given in Table V(b).

Although the application of ammonium sulphate gave higher yield of grain and *karbi* than control but the increase was not significant. The crop sown early gave a little higher yield of grain but the *karbi* production was depressed though not significantly as compared to that sown at the normal time. It was probably due to the lesser plant population per unit area in the pre-monsoon sown crop which could compensate for the grain yield only.

Since ammonium sulphate at 10 to 30 lb. N per acre applied at the time of sowing did not give any significant response in the previous two seasons, it was thought desirable to use it alone and mixed in different proportions with groundnut cake and applied as a top dressing after about a month of germination to supply 20 lb. N per acre. The premonsoon and normal sowings were done on the 18th June and 4th July respectively and the rainfall between two dates was 2·94 inches. The spacing of 9 and 18 inches between the plants within the row was also included for study. Here again the layout was of a split plot design in which the sowing dates were randomised in main plots and manures and spacing between the plants were randomised in the sub-plots. There were four replications and the experimental plot size was 1/117th acre. The yields in lb. per acre are given in Table V(c).

It will be observed from the above figures that the differences in yield of grain and *karbi* were not significant either due to sowing dates or spacing. The application of ammonium sulphate alone or mixed in different proportions with groundnut

cake, too, did not increase the yields significantly over control although there were indications to show that higher yield of grain and *karbi* may be obtained with the application of ammonium sulphate.

TABLE V(c). GRAIN YIELD

Manures	Pre-monsoon sowing		Normal sowing		Mean		Overall mean for manures
	9 in	18 in.	9 in.	18 in.	9 in.	18 in.	
*M_0	351	373	331	296	341	334	337 S.E.±25
M_1	476	388	382	395	429	391	410 C.D. at 5 per-cent. Not sig.
M_2	432	366	285	353	358	359	358
M_3	392	373	355	432	373	402	387
Mean	413	375	338	369	375	372	
Mean for sowing date	394				353	S.E.±17	
					C.D. at 5 per cent. Not sig.		

S.E.±41
C.D. at 5 per cent. Not sig.

KARBI YIELD

M_0	2545	2164	2252	2223	2398	2193	2295	S.E. ±147
M_1	2603	2983	2896	2428	2749	2705	2727	C.D. at 5 per cent. Not sig.
M_2	2632	2164	2135	2398	2383	2283	2332	
M_3	2486	2252	2866	3447	2676	2849	2762	
Mean	2566	2391	2537	2626	2551	2508		

S.E.±104
C.D. at 5 per cent. Not sig.

Mean for sowing date 2478 2581
S.E.±405
C.D. at 5 per cent. Not sig.

*M_0 No manure

M_1 20 lb. N as ammonium sulphate

M_2 20 lb. N(75 per cent N as ammonium sulphate, 25 per cent. N as groundnut cake)

M_3 20 lb. N(50 per cent N as ammonium sulphate, 50 per cent. N as groundnut cake)

By considering the results of the three seasons it may be concluded that the application of ammonium sulphate gives higher yields of both grain and *karbi* than no manure. The dose, however, may vary from 10 to 20 lb. N per acre. Pre-monsoon sowing is also advantageous as the yields achieved thereby are not significantly lower than the crop sown after the break of monsoon. The precaution to be taken in the pre-monsoon sowing is that the seeds should be thoroughly covered with soil and the sowing should not be done earlier than second week of June under the local conditions.

ROTATION

In *Malwa* plateau, *jowar* is generally grown in rotation with *rabi* crops, particularly wheat, preceded either by cotton or some leguminous crops like *mung*, *urid*, cowpea and sannhemp, etc., grown for green manuring or as catch crops. The results of these trials are discussed below.

During 1951-52 two green manures, viz., sann hemp and soyabean and two catch crops, viz., *urid* and *mung* were grown with and without the application of superphosphate at 30 lb. P_2O_5 per acre. A fallow plot was also left for comparison. The treatments were randomised in a simple randomised block design with 4 replications and 1/42nd acre plot size. Wheat (*Malvi* EK. 69) grown in the following *rabi* season failed due to severe droughty conditions. The same plots were, subsequently, sown with *jowar* I.P.I. 3 in 1952 *kharif*. The yields of grain and *karbi* in lb. per acre are given in Table VI.

TABLE VI. YIELD OF GRAIN AND *KARBI*

Preceding crops	Grain in lb. per acre					*Karbi* in lb. per acre				
	0	30	Mean	S.E.	C.D. at 5 per cent.	0	30	Mean	S.E.	C.D. 5 per cent
Fallow	1392	1278	1335	±84	245	5533	5862	5697	±215	631
Mung (C.C.)	1555	1608	1581			6010	7431	6720		
Soyabean (G.M.)	1619	1597	1608			8098	8544	8321		
Sannhemp (G.M.)	1488	1802	1645			7876	8141	8008		
Urid (C.C.)	1672	1958	1815			6784	8395	7589		
Mean	1545	1649				6860	7674			
	S.E.±53					S.E.±137				
	C.D. at 5 per cent. Not sig.					C.D. at 5 per cent. Not sig.				

C.C. for catch crop
G.M. for green manuring

The grain and *karbi* yields of *jowar* were considerably increased when it followed the leguminous crops grown for green manuring and as catch crops. The grain yields obtained with green manuring of sannhemp and catch crop of *urid* were significantly higher than that of fallow although it did not differ significantly either amongst them or from the yield obtained with green manuring of soyabean and a catch crop of *mung*. The *karbi* yields obtained with green manuring of soyabean and sannhemp were significantly higher than that obtained after catch crops or fallow. The application of superphosphate to preceding legumes also gave higher yields of grain and *karbi* than that without it but the difference was significant in *karbi* out-turn only. However, no significant interaction was observed between the legumes and phosphate application.

In the year 1952-53 several legumes, viz., sannhemp, *dhaincha*, *mung*, *sindhkera*, *Mung* Type 1, *Mung* Local, cowpea, soyabean, *urid*, *guara* and *Sesbania speciosa* were grown for green manuring with and without the application of superphosphate at 30 lb. P_2O_5 per acre. The treatments were randomised in a simple randomised block design with 4 replication and 1/52nd acre plot size. In the following *rabi*, wheat was grown on these plots which was followed by *jowar* in *kharif*, of 1953-54. The results for *jowar* are given in Table VII.

TABLE VII. YIELDS IN LB. PER ACRE

Legumes	Grain					*Karbi*				
	0	30	Mean	S.E.	C.D.	C.D.	30	Mean	S.E.	C.D.
Fallow	887	800	843	±108	Not sig.	2865	3059	2962	±280	Not sig.
Dhaincha	837	1027	932			2943	3630	3286		
Mung T. 1	998	1073	1035			3747	4135	3941		
Mung Sindhkhera	967	1133	1050			3254	4382	3818		
Sannhemp	769	946	857			3573	3370	3474		
Urid	855	1043	949			3150	4161	3655		
Cowpea	1195	984	1089			3850	3876	3863		
Soyabean	810	837	823			3293	2969	3131		
Sesbania specios	882	724	803			3448	2593	3020		
Guara	963	839	901			3539	3202	3370		
Mung Local	902	1105	1003			3487	4213	3850		
Mean	915	955				3378	3599			
S.E.±46						S.E.±119				
C.D. not sig.						C.D. not sig.				

Although the yields of grain and *karbi* after G.M. legumes were not significantly higher than fallow but the indications are to show the usefulness of *Mung* Type 1, *Mung-Sindhkera*, *Mung* Local, *urid* and cowpea for green manuring under *barani* conditions, particularly when superphosphate is applied to them.

In the year 1953-54, all the legumes except *Sesbania speciosa* mentioned in the previous year's experiments were repeated with and without the application of superphosphate at 30 lb. P_2O_5 per acre. The green matter was buried *in situ* after five and seven weeks' growth. The trial was laid out in a split plot design with 4 replications. The burying dates were randomised in the main plots while the other treatments were randomised in the sub-plots each of 1/78th acre size. These plots were grown with wheat in the following *rabi* season and then with *jowar* in the *kharif* of 1954. The yields of *jowar* in lb. per acre are given in Table VIII.

TABLE VIII. YIELD OF GRAIN IN LB. PER ACRE

Legumes	Buried after 5 weeks			Buried after 7 weeks			Overall Mean
	0	30	Mean	0	30	Mean	
Fallow	616	577	596	672	605	638	617
Dhaincha	668	595	631	559	721	640	535
Mung Type 1	624	618	621	697	641	669	645
Mung Sindhhera	636	617	626	610	780	695	660
Sannhemp	483	650	566	760	710	735	650
Urid	632	575	603	639	648	643	623
Cowpea	541	531	536	610	610	610	573
Soyabean	593	638	615	648	627	637	626
Guara	573	572	572	646	557	601	586
Mung Local	511	599	555	542	670	606	580
Mean	588	597	592	638	657	647	

S.E. for burying dates ±132
S.E. for levels of P_2O_5 ±11
S.E. for legumes and fallow ±25

Yield of karbi in lb. per acre

Fallow	3139	2925	3032	2496	2954	2730	2881
Dhaincha	3490	3685	3587	3276	3646	3461	3524
Mung Type 1	3276	3256	3266	3276	3159	3217	3241
Mung Sindhkhera	3198	3061	3129	3159	3412	8285	3207
Sannhemp	3666	2847	3256	3276	3705	3490	3373
Urid	3061	3159	3110	3270	3510	3390	3250
Cowpea	2769	2905	2837	2964	3510	8237	3037
Soyabean	3081	3120	3100	8627	3159	8393	3246
Guara	3217	3198	3207	3178	8217	3197	3202
Mung Local	3334	2691	3012	3159	8334	3240	3129
Mean	3223	3085	3154	8168	3362	3265	

S.E. for burying dates ±373 C.D. Not sig.
S.E. for levels of P_2O_5 ±40 C.D. Not sig.
S.E. for legumes vs. fallow ±90 C.D. 251

Fallow	Cowpea	*Mung* Local	*Guara*	*Mung Sindh-khera*	*Mung* T.1	*Soyabean*	*Urid*	Sann-hemp	*Dhaincha*
2881	3037	3129	3202	3207	3241	3246	3250	3373	3524

Interactions burying dates $\times P_2O_5$

Levels of P_2O_5	Buried after 5 weeks	Buried after 7 weeks	Mean
0	3223	3168	3195
30	3085	3362	3223
Mean	3154	3265	
S.E.	±56		
C.D.	157		

A perusal of grain and *karbi* yields given in Table VIII will show that none of the treatments or their interactions were found to be significant in case of grain yield while *karbi* yield obtained after green manures, except cowpea, *Mung* Local, was significantly higher than that of the fallow and *dhaincha* proved significantly superior to other legumes (excluding sannhemp). Also the interaction between burying dates and phosphate application was significant showing thereby that the *karbi* outturn was significantly increased when green manures supplemented with 30 lb. P_2O_5 per acre were buried *in situ* after seven weeks growth.

It is evident from the results that green manuring *in situ* does not give any good scope under rainfed conditions hence the trial has been modified to study the effect of short-duration legumes like early *mung*, cowpea, *urid*, etc., grown for green manuring as well as for catch cropping on the yield of wheat and *jowar* in succession.

SUMMARY

The article summarises the results of the agronomical experiments on *jowar* conducted at the Institute during the last eight years (1947-48 to 1954-55) under different conditions of manuring and other agronomical practices. The conclusions drawn are as follows:

The application of groundnut cake at 20 and 40 lb. N per acre increased the yield of *jowar* significantly over control but the doses of N did not differ significantly amongst them. The response per lb. of nitrogen was of a higher magnitude with 20 lb. N than with 40 lb. N.

The difference in the yield of *jowar* was not significant with basal dressing as compared with no basal dressing. The analyses of variance showed that the yields were generally increased significantly with the application of nitrogen alone in the presence and absence of farm compost and superphosphate.

The application of 20 lb. N as ammonium sulphate was also found to give the highest net money returns.

Ten pounds per acre was found to be the optimum seed rate for which thinning operation, too, is not required except removing the plants at crowded spots and that ammonium sulphate at 20 lb. N per acre may be applied to get higher yields.

Drilling the seeds in dry soil before the break of monsoon seemed to be a sound practice for getting higher yields by taking advantage of early light showers.

In addition, it would spare more time to the cultivators for attending to other operations during the busy sowing period.

Green manuring *in situ* does not seem to be a sound practice under rainfed conditions. It is, therefore, desirable to know how far short duration legumes like early *mung*, *urid* and cowpea, etc., can help to replace green manuring by growing them as catch crops and the experiments to study this aspect are in progress at the Institute.

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APPENDIX A

MINIMUM AND MAXIMUM LIMITS OF WEEKLY RAINFALL RECEIVED DURING MONSOON PERIOD (1924-1953)

Weeks*	Date†	Minimum (inches)	Maximum (inches)	Mean (inches)
23	10th June	0·00	0·77	0·29
24		0·14	1·25	0·66
25		0·56	2·00	1·50
26	1st July	0·33	4·11	1·97
27		1·26	3·94	2·48
28		1·32	3·78	2·45
29		0·93	4·25	2·41
30		1·21	4·46	2·66
31	5th August	0·79	3·88	2·17
32		0·79	3·40	1·97
33		0·42	2·76	1·48
34		0·57	3·18	1·75
35	2nd September	0·79	4·19	2·18
36		0·39	3·63	1·82
37		0·37	3·30	1·67
38		0·45	2·57	1·42
39	30th September	0·04	1·80	0·56

* From 1st January.
† Date of commencement of week.

The minimum and maximum expected rainfall shown in Appendix A is calculated for 0·5 probability. The agreement between the expected and observed frequencies is for the entire monsoon period of 17 weeks.

A NOTE ON *MUSA CHILIOCARPA* BACKER

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Backer (1907) was probably the first person to record the occurrence of *Musa chiliocarpa*. Ochse (1931) reported that this species was called *Tjaoo boohaya*, *Peesang sereeboo*, and *Gedang sewoo* in local dialects of Malaya and Java; and characterised it as a botanical curiosity, distinguishable from others by the reverse position of the staminate and pistillate flowers, i.e., the male flowers are produced ahead of the pistillate. In the Philippines this species has produced a rachis, many portions of which are vacant due to the alternating male and female phase. It is stated that the number of fertile flowers is almost unlimited and consequently, the fruiting rachis which is very compact can be of enormous length. Ochse quoted that a specimen of *Peesang sereeboo* was described (*Teysmannia* 14. 1903) with the fruiting rachis as long as 1·96 metres, consisting of 151 hands and numbering about 3134 fruits.

The exceptionally large fertility ratio recorded in this species has breeding importance. In India, many cultivated varieties are of poor bunching capacity, e.g., *Rasthali* (*Syn.* Silk fig, *Amirthapani*, Martaman, *Hadagalli*, *Benares*), *Kadali*, *Sirumalai*, *Virupakshi*, *Pacha Nadan* (*Gale Bale*), Red Banana, etc., in the dessert group; and Monthan (*Syn. Kanchkela*, *Madhuranga Bale*, *Bluggoe*) *Nendran* (*Rajeli*), etc., in the cooking group. In order to improve the grade of bunches in the cultivated varieties, *M. chiliocarpa* was introduced, from the Philippines, at the Central Banana Research Station, Aduthurai, for investigations.

DESCRIPTION

Pseudostem : One hundred and ninety-six to 230 cm. in height, 18 cm. in diameter at base, green with dark patches, leaf sheath and petiole slightly waxy.

Leaf: Blade oblong, 140 to 160 cm. long, about 60 cm. wide, colour of lamina and mid-rib dark green on upper surface and light green in lower surface, petioles 29 to 33 cm. long, margins well curved, loosely clasping the pseudostem, margin red tinged, adaxial channel open.

Inflorescence: Sub-horizontal in early stage and pendulous later, peduncle glabrous, basal flowers female in first two or three hands followed by a phase of large number of hermaphrodite flowers arranged in two rows per bract, compound petal yellow on the outer surface with two prominent ridges, margins hyaline, 5·6 to 5·9 cm. long, three outer and two inner lobes yellowish, 3 to 5 mm. long, free petal occasionally absent, translucent white with yellowish streaks and mucronate apicula; fertile stamens varying from 1 to 5 , the number increasing gradually as the inflorescence develops, in the first two or three hands well developed stamens are completely absent; pollen present only in the late stages of hermaphrodite phase; stigma exerting stamens in some cases, filaments 4 to 5 cm. in length, white in colour, anther lobes pink turning brown, 3 to 3·5 cm. long; ovary 4 to 5 sided, pale green 5 to 6 cm. in length; style length about

5 cm.; thin, yellow in colour; stigma club shaped, yellow in colour; male flowers without marked variations from the hermaphrodite flowers except for the small functionless ovary which is yellowish and for the deciduous nature of the flowers. Peduncle glabrous, green, pendent, 60 to 90 cm. long.

Fruit: Axis 72 to 76 cm. in length; hands 34 to 39, fruits 400 to 800; compact except for the first three or four hands, fruits small, terete, about 6 cm. long, 6 to 7 cm. in girth, apex blunt with a button like stigmatic scar, pedicel 1·3 to 1·6 cm. in length, angular ribs not distinct, floral parts persistent in few cases, fuits green when mature, bright yellow on ripening, pericarp 2 mm. thick, flesh, cream coloured, fairly sweet. Seed setting not observed at the Central Banana Research Station, Aduthurai.

Suckering: Rather sparsely.

Musa chiliocarpa displayed predominantly the traits of *Musa acuminata* except for the characters detailed in Table 1.

TABLE 1. DIFFERENTIAL CHARACTERS OF *MUSA CHILIOCARPA* AND *MUSA ACUMINATA*

Characters	*Musa chiliocarpa*	*Musa acuminata*
Pseudostem	Dark blotches only near the petiole, absent elsewhere	Coloured pink with dark blotches
Petiole	Waxy bloom moderate	Waxy bloom sparse
Leaf sheath	Clasping the pseudostem loosely	Same
Basal flowers	Hermaphrodite (first two or three hands female only)	Female
Pollen in male flowers	Sparse to moderate	Plenty
Fruit	5 to 6 cm. long	8 to 10 cm. long
Shape	Terete with blunt apex	Terete with pointed apex
Crown of apex	Withered floral parts often persistent	Withered floral parts deciduous
Seeds	Ordinarily not produced	Produced in plenty, dull white in colour without angles

Cheesman (1948) reported that *Musa banksii* was the only species in *Musa* which produce hermaphrodite flowers. But *M. chiliocarpa* also produced hermaphrodite flowers at the Central Banana Research Station. Further, it showed a distinct tendency to produce sterile and fertile flowers alternately. The bunch characters, reported here fall short from the observations recorded by Ochse. Perhaps, the wild habitat in the equatorial forests of South East Asia accounts for the high vigour and fertility in contrast to the milder climate obtaining at Aduthurai and this moderate fertility could be exploited for breeding work. The numerical strength of fruits and compactness of the bunch noticed in this species offer an opportunity for the between to improve the grade of the bunch in the existing commercial varieties[1].

[1] The species has been successfully crossed with four cultivated varieties at the Central Banana Research Station, Aduthurai, and the seedling progenies are under study.

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GROWTH PROMOTING SUBSTANCES AND ROOTING OF CUTTINGS IN *GLIRICIDIA MACULATA*

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Gliricidia maculata, H.B. and K. is a perennial shrub grown for green manure in South India. Great difficulty has been experienced in securing seed material of this plant for propagation. Propagation by seed and stem cuttings offer only a limited scope. Small quantities of seeds are, however, obtained during early dehiscence of the fruit. The percentage of stem cuttings that could be established under normal conditions is also low on account of their poor rooting habit. Observations made by the authors regarding rooting of stem cuttings during the months of May, June and July 1958, under different soil types showed that hardly 10 per cent of the cuttings rooted. This discouraging result prompted us to take up the present investigation on the influence of some growth-promoting substances on rooting. The trials were conducted on the College Farm during July-September 1958.

MATERIAL AND METHODS

The first set of experiment was started in July 1958 by treating the cuttings collected from well established plants with solutions of indoleacetic acid, indolebutyric acid, indolepropionic acid and naphthaleneacetic acid at concentration 10000 p.p.m., 1000 p.p.m., 100 p.p.m., and 10 p.p.m., individually and in combinations of IAA+IBA; IBA+NAA; IAA+NAA and with pregnant cow's urine collected the previous evening. The cuttings were dipped in these solutions for 24 hours. Treatments were also made with hormonol powders mixed with talc. The proportion of the mixture was 1 gm. of talc+2 mg. of NAA; 1 gm. of talc+2 mg. of IAA+2 mg. NAA and 1 gm. of talc + 2 mg. IBA+2 mg. NAA. The cuttings were dipped in the powder just at the time of planting. One set of cuttings was also smeared with cow-dung slurry and all the cuttings were transferred to the specially prepared bed for rooting.

OBSERVATIONS

The results of observations made 28 days after planting are recorded in Table I.

The effect of IAA, IBA and NAA in aqueous solutions at 10000 p.p.m. and 1000 p.p.m. individually and in combinations with other hormones when used as powders at the rate of 2 mg. of NAA+2 mg. of IBA in one gram of Talc. was significant. But, at 10000 p.p.m. in solution, the root development was not satisfactory as compared to that of 1000 p.p.m.

The second set of experiment was started in August 1958. Three types of stem cuttings used were (*a*) cuttings aged between one year and one and a half years (Hard); (*b*) cuttings aged between six months and one year (medium); (*c*) cuttings

TABLE I. PERCENTAGE OF CUTTINGS ROOTED IN EACH TREATMENT

Hormones used	10000 ppm	1000 ppm	100 ppm	10 ppm
Aqueous solutions				
Control	0	0	0	0
Indoleacetic acid	20	60	0	0
Indolebutyric acid	80	80	40	20
Indolepropionic acid	20	0	20	0
Naphthaleneacetic acid	20	100	0	20
Indoleacetic acid 100 ppm+Indolebutyric acid 100 ppm	40	..	..	..
Indolebutyric acid 100 ppm+Naphthaleneacetic 100 ppm	0	..	..	..
Indoleacetic acid 100 ppm+Naphthaleneacetic acid 100 ppm	20	..	..	..
Cow's urine	0	..	..	..
Powders:				
Talc	20	..	..	..
1 gram talc+2 mg. NAA	20	..	..	..
1 gram talc +2 mg. IAA+2 mg. NAA	40	..	..	..
1 gram talc +2 mg. IBA+2 mg. NAA	80	..	..	..
Cow dung slurry	20	..	..	..

TABLE II. THE MEAN PERCENTAGE OF CUTTINGS ROOTED IN THE THREE DIFFERENT KINDS OF WOOD

Type of wood	Mean percentage of rooted cuttings	Critical difference
Hard	65	
Medium	46	39·20
Soft	13	

aged less than six months (soft). The leaves which were allowed to remain on soft wood cuttings were found to wither and fall off four to five days after treatment. The cuttings were immersed in solutions of IAA, IBA and NAA at 1000 p.p.m. for 24 hours. The cuttings were first dipped in water then dipped in the powder of harmone mixed with talc in the proportion of 2 mg. of IBA+2 mg. of NAA to every gram of talc as per standard dip method. The cuttings then were planted in a split plot design with

TABLE III. MEAN PERCENTAGE OF CUTTINGS ROOTED UNDER DIFFERENT TREATMENTS

Treatment	Concentration	Mean percentage of rooted cuttings			Critical difference
		Hard wood	Medium wood	Soft wood	
IAA	1000 ppm.	80	70	15	
IBA	1000 ppm.	90	70	45	
NAA	1000 ppm.	95	60	00	12.00
Talc (1 gm.)+ IBA (2 mg.)+ NAA (2 mg.)	..	60	25	5	
Control	..	00	5	00	

TABLE IV. OBSERVATIONS ON ROOTING

Treatment	Type of wood		
	Hard	Medium	Soft
IAA 1000 p.p.m.	N	S	N
IBA 1000 p.p.m.	P	S	P
NAA 1000 p.p.m.	P	S	..
Talc (1 gm.)+IBA (2 mg.)+NAA (2 mg.)	N	N	N
Control	..	N	..

four replications of five cuttings each. The observations were made after 32 days and are recorded (Tables II-IV).

Though, roots were formed under most of the treatments, some difference in the nature of root formation, between treatments was apparent and, therefore, they were classified into three categories, viz. 'profuse' where a large number of healthy roots were formed (*P*); 'sparse', where only a few healthy roots were observed (*S*); and 'negligible' where one or two feebly developed roots were found (*N*). The observations made on rooting are recorded (Table IV).

DISCUSSION

Differential rooting response of cuttings according to age and position of plant from which cuttings are taken (Avery *et al.*, 1947) was obvious from the fact that the highest number of cuttings rooted profusely in hard wood as compared with lower and lowest number of cuttings rooted sparsely in medium and soft woods. It seemed probable that the older the stem cuttings, the more the rooting response and so better suited for propagation.

Of the three harmones IBA and NAA seemed to induce better rooting than IAA. IBA proved superior to NAA with soft wood cuttings.

Sen Gupta and Chattopadhaya (1954) recorded that rooting response was intimately connected with the penetration of hormones through epidermis and cortex up to the pericycle region, and probably explained why a high concentration is required in the case of woody species. This is further strengthened by observation of better rooting response of *Gliricidia* cuttings with higher concentration of IAA, IBA, and NAA.

Cooper and Stoutmeyer and Vanoverbeek (c.f. Sen Gupta and Chattopadhaya, 1954) stated that leaves developed on cuttings which are supposed to supply co-factors necessary for rooting of cuttings irrespective of the presence of auxin, could not be confirmed by us as better rooting was found only in hard wood cuttings which were devoid of leaves. Soft wood cuttings with leaves, were in no way equal to or better than either medium or hard wood cuttings in their rooting response.

SUMMARY

Possibility of using a harmone effective in inducing early rooting on cuttings of *Gliricidia maculata* was attempted.

Indole butyric acid and naphthalene acetic acid at 1000 p.p.m. were found superior to others in producing roots in about 28 to 32 days after treatment.

Cuttings from more than a year old stem seemed to be good for propagation.

Retention of leaves on the cuttings to induce early rooting showed no superiority to those devoid of leaves.

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STUDIES ON *BEIJERINCKIA* FROM SOME ACID SOILS IN INDIA

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The isolation of a nitrogen fixing organism closely resembling *Azotobacter* by Altson (1936) from acid soils of Malaya was afterwards followed by that of *Azotobacter indicum* by Starkey and De (1939) from the acid soils of Dacca. The organism was studied in detail by Starkey (1939). Since then isolation of several acid tolerant aerobic nitrogen fixing organisms were reported, among others by Derx (1950), Kauffmann and Toussaint (1951), Tchan (1953, 1957) and Jensen (1955).

Derx (*loc. cit.*) observed sufficient prominent differences in the characteristics of these organisms from those of *Azotobacter* to include the former into a new genus *Beijerinckia*. Considerable controversy remains regarding the usefulness of taking these acid tolerant organisms to be different species of *Beijerinckia* in contrast to considering them to be different varieties or strains of *Azotobacter indicum* (Bergy 1957; Breed, Murray and Smith, 1957).

The importance of these groups of organisms resembling *Azotobacter* spp. and having almost similar efficiency of nitrogen fixation in the nitrogen economy of tropical soils, where deficiency of lime and phosphate are serious limitations on the growth and activity of *Azotobacter* spp. were recently stressed by Meiklejohn (1954, 1955). Wide occurrence of these organisms in the phyllosphere of numerous tropical plants (Ruinen, 1956) where they may be living in symbiosis, somewhat similar to the Rhizobia in the case of leguminous plants, has made the study of the organisms assume a good deal of importance in the field of agricultural science.

Apart from the isolation of the organisms in the paddy soils of Dacca by Starkey *et al.* (*loc. cit.*) very little information is available regarding the occurrence of *Beijerinckia* (*Azotobacter indicum*) in Indian soils. There is little doubt, however, that the organism was noticed unidentified by many workers during the course of their investigations on nitrogen fluctuations in Indian soils. The organism suspected to be capable of fixing atmospheric nitrogen in association with rice plants (Sen, 1929), the one probably responsible for increase in nitrogen content during the growth of crop in swampy rice soils of Travancore (Iyer, 1929) and the species of *Azotobacter* observed by Uppal *et al.* (1939) in the rice soils at Karjat, which was found to be stimulated to greater activity in association with growing roots of the crop are all probably one or the other species of *Beijerinckia*.

Tchan (1953) investigated, in detail, the distribution of *Beijerinckia* in North Australian soils. The occurrence of the organism was found to be restricted to the tropical part of the Australian continent (latitude 17°–18° N). Dommergues (1954) has recently reported the existence of *Beijerinckia* (*Azotobacter lacticogenes*) originally isolated from acid forest soil of Ivory Coast (lat. 5°-10° N) in certain soil types of Madagaskar at Tananarive (lat. 20°S).

Kluyver and Becking (1955) examined nearly 50 soils from different parts of Europe and observed that *Beijerinckia* spp. were absent in European soils. They could find *Beijerinckia* in abundance in several soils of Indonesia which were more or less lateritic in character but none in an alkaline clay deposit. The organisms was also observed to be present in South America in acid rice and lateritic soils. It was, however, absent in a podsolic forest soil under the intermittent action of ground water.

Geographic distribution of *Beijerinckia* so far studied tends to show that the occurrence of the organism is mostly confined to tropical parts on laterites and lateritic formations. The present work is an attempt to find out the distribution of the organism in Indian soils based on the examination of 50 surface soils from different parts of the country. Wherever present, the organism has been isolated in pure cultures and studied. Their possible occurrence in Indian soils has also been discussed.

MATERIAL AND METHODS

A description of the soils which were examined for the presence and used for isolation of *Beijerinckia* is given below:

Assam (*latitude*—25-27° *N*).

1A—Baghmari, farm area, Darrang District; dirty brown sandy loam soil
2A—Kothiatoli, farm area, Nowgong district; greyish brown silt loam
3A—Jorhat, farm area, Sibsagar district, light brown sandy loam
4A—Shillong, fruit farm, Khasia and Jantia Hills district, red sandy soil
5A—Bornihat, Citrus Research Station, Khasia and Jantia Hills district, dark brown loam
6A—Tinsukia, seed farm, Lakhimpur district, greyish brown sandy soil
7A—Kharpeta, Darrang District, whitish grey sandy loam
8A—Golaghat, Sibsagar district, greyish yellow sandy loam
9A—Kanhikuchi, Cocoanut Cultivation Scheme area, Kamrup district; grey sandy loam
10A—Gauhati, Fruit farm, Kamrup district, greyish brown sandy loam
11A—Puranihapagoan, Darrang district; well drained paddy field grey loam
12A—Mangoldai, Darrang district, dark grey sandy soil
13A—Place unknown, Darrang district, paddy field, grey sandy soil
14A—Sherpeng, Darrang district, paddy field greyish yellow silt loam
15A—Budhagoan, Darrang district, eroded paddy field, greyish yellow sandy loam
16A—Lumding, on edge of the town; sugarcane field in clear jungle, unmanured greyish black sandy soil

West Bengal (*latitude*—26-27° *N*).

1WB—Phansidewa, Siliguri, greyish white loam
2WB—Kharibari, Siliguri, grey sandy soil
3WB—Naxalbari, Siliguri, greyish black sandy soil
4WB—Siliguri, greyish white loam

Tripura (*latitude*—23-24½° *N*)

1T—Dhaleswar, paddy field, dirty yellow loam

2T—Chandannagar, low lying paddy land, dark grey, sandy clay

3T—5T—Agartola, from different sites in paddy field, dark grey loam to grey loam

6T—Abhoynagar, paddy field with free drainage fertilised with nitrogenous fertilizers

Bihar (*latitude*—24-24½° *N*).

1B—Unknown village in Santal Parganas, paddy field, treated with farmyard manure, light brown sandy loam

2B—Nijhuri, paddy field, treated with farmyard manure, light brown loam

3B—5B—Raneswar Community Project area, paddy fields, greyish yellow sandy loam to sandy clay

6B—Pakuria, Raneswar Community Project area, well drained paddy field, greyish pink clay loam

Kerala (*latitude*—6½-12¾° *N*).

1K-11K—Different sites in Kunnathunad Chalakudy Community Project area, mostly sandy loam

Mysore (*latitude*—30° *N*).

1M-5M—Different sites in the neighbourhood of Bangalore

6M—Kavathar, greyish pink sandy soil

Bombay (*latitude*—16-20° *N*).

1By—Thana, high level ground, paddy field, coffee brown clay soil

The composition of the soils is given in Appendix I. The analysis of the soils was carried out by the usual methods of analysis (Wright, 1934).

Isolation of Beijerinckia: In the earlier experiments Derx's liquid enrichment medium consisting of distilled water glucose 2 per cent, KH_2PO_4 1 per cent and $MgSO_4$, $7H_2O$ 0·05 per cent was used. The pH value of the medium was about 5·0. 5 cc. of the medium were poured into a Petri dish of 9 cm. diameter and spread all over the dish so as to bring down the thickness of the layer to 2-3 mm. to reduce butyric acid fermentation. The amount of soil used for inoculation was about 0·6 gm. After incubation for about a week, the liquid was examined under the microscope for the characteristic morphology of *Beijerinckia*. The findings were confirmed by streaking on agar plates containing agar 2 per cent, glucose 2 per cent, K_2HPO_4—0·1 per cent, $MgSO_4$, $7H_2O$–0·05 per cent, $FeCl_3$, $6H_2O$—0·01 per cent, Na_2MoO_4, $2H_2O$—0·002 per cent, $CaCl_2$, $2H_2O$—0·005 per cent. This method of testing soils for the presence of *Beijerinckia* and isolation of pure cultures, however, proved unsatisfactory since, among some fifteen isolates, only four were found to be capable of fixing atmospheric nitrogen. The rest showed transparent growth in Derx's agar medium without many essential characteristics of *Beijerinckia*.

After repeated trials with different media, the following enrichment medium also due to Derx (*loc. cit.*) showed presence of *Beijerinckia* with the usual characteristics

like the tough muciligenous growth and fixation of atmospheric nitrogen: distilled water 100 cc., glucose 2 gm., KH_2PO_4 0·08 gm., K_2HPO_4 0·02 gm., $MgSO_4$, $7H_2O$— 0·05 gm., $FeCl_3$ $6H_2O$ 0·01 gm., Na_2MoO_4, $2H_2O$ 0·002 gm., $CaCl_2$ $2H_2O$ 0·005 gm. Sometimes, the growth on the streaks were replaced in several dilutions and the transfers made from widely separated colonies in the dilution plates.

Isolation and purification of the cultures of Beijerinckia: In the method, originally recommended by Derx, the fungal growth in some cases became noticeable even on the second day of inoculation and it slowly formed a heavy mat. After a week, almost in all cases, growth of fungi covered the whole of the liquid in the Petri dishes. There were no slime or tough growth of *Beijerinckia.*

The presence of *Beijerinckia* was checked by streaking on agar medium. It was observed that on the second day of streaking, in some plates, there were raised transparent growth, contaminated with fungi and other micro-organisms. In quite a good number of plates, fungi overgrew bacteria which might have grown otherwise. A good number of streak plates had to be discarded as there were no bacterial growths of desired characteristics but heavy fungal development.

Purification of crude cultures was carried out by dilution plate technique. The cultures were purified by taking a little growth of the organism from the vigorously growing areas of the streaks and by repeated plating and selection of solitary and well growing colonies. To purify some cultures as long as two months were needed. It was noticed that in some cases, growth ceased after repeated plating. It was also observed that some cultures when transferred to slants did not grow equally well in all slants, even to the extent that in some slants there was no visible growth at all without any apparent cause.

Unlike heavy fungal growth in the isolation medium used earlier by Derx, there was little or no fungal growth to interfere with the free development of *Beijerinckia* in the medium finally used. Only in a very few cases, there was fungal growth which could be ascertained from examination of the plates through magnifying glass. When there was fungal growth in the Petri dishes, soil particles got aggregated and it was difficult to loosen them by simple shaking. When there was growth of fungi it was usually not heavy when the final medium was used.

In some plates, white raised shining growth around some soil particles were observed after a week. Day to day observation was made and it was found that more and more plates were showing similar growth and after 15 days no new growth was observed in Petri dishes; when fungi grew, they grew in the medium around and on the bacterial slime. In case *Beijerinckia* was present in the soil, there was definite slime formation frequently round the soil particles covering partly or sometimes wholly the entire surface of the plate and the culture liquid exhibited a very slow flow on slanting the dish. As soon as slimy growth was observed streaks were drawn to avoid fungal contamination and to ensure rapidity in purification. Streaking was done by taking a loopful from the slimy growth but it was almost with difficulty that some portion of the slimy growth could be taken out. It was sometimes so tough and tenacious that along with the needle the whole mass came out. One loopful, in almost all the cases was sufficient to draw streaks. After fourth day of streaking abundant growth was noticed. The growth was highly raised,

slimy and often shining. In a few cases, growth of streaks was very poor though there was abundant growth in the isolation medium. When the growth was contaminated with fungi it assumed yellowish or brown colour. In some cases, even in the third set of planting, good uncontaminated solitary colonies were obtained; in majority of cases, however, time of purification was prolonged due to tenacious association of the fungi with the organism.

In the morphological, cultural and physiological studies on the isolates methods in the Manual of Methods (Committee on Bacteriological Technic, Society of American Bacteriologists, 1944) were followed.

Nitrogen fixing capacity: Nitrogen fixing capacity of the isolates was determined in the latter medium. The sterile liquid medium (25 cc.) was inoculated with a loopful of growth and incubated for one month at 30°C. The growth was usually characterised by change of the culture liquid to a transparent gum. The nitrogen content of the culture liquid was determined by modified Kjeldahl method of digestion.

RESULTS

The soils which showed the presence of *Beijerinckia* and those where it could not be isolated are given in Table I.

TABLE I. PRESENCE AND ABSENCE OF BEIJERINCKIA IN INDIAN SOILS

State	No. of soils where *Beijerinckia* was present	No. of soils where *Beijerinckia* was absent
Assam	8 (2A, 4A, 5A, 6A, 7A, 12A, 15A, 16A)	8 (1A, 3A, 8A, 9A, 10A, 11A, 13A, 14A)
West Bengal	3 (2WB, 3WB, 4WB)	1 (1WB)
Bihar	2 (2B, 3B)	4 (1B, 4B, 5B, 6B)
Tripura		6 (1T, 2T, 3T, 4T, 5T, 6T)
Kerala	4 (1K, 8K, 9K, 10K)	7 (2K, 3K, 4K, 5K, 6K, 7K, 11K)
Mysore	2 (1M, 6M)	4 (2M, 3M, 4M, 5M)
Bombay	1 (1By)	

It was evident, therefore, that *Beijerinckia* spp. occurred in 20 out of 50 soils examined. No *Beijerinckia* spp. was observed in the soils of Tripura.

The morphological characteristics of the strains isolated are given in Table II. The organism appeared as small rods, some were oval shaped; and some of the cells showed a tapering end. There was no regularity of shape. Invariably in all cases, a highly refractive body or bodies was or were observed. Due to the presence of refractive body or bodies at different stages of growth the shape seemed variable.

The growth varied in toughness. The organism was gram negative and non capsulated.

TABLE II. MORPHOLOGICAL CHARACTERISTICS OF *BEIJERINCKIA* ISOLATED FROM INDIAN SOILS

Habitat	Characteristics
2A	Rods and oval shaped bodies, rods were with two fat globules and oval shaped ones with one, 2.5 $\mu \times 1{\cdot}39$ μ, tough growth
4A	Mostly rods with two fat globules; cell with three fat globules few in number, some cells with one fat globule, the size of the fat globules varied markedly from one another, $2{\cdot}48$ $\mu \times 1{\cdot}41$ μ, tough growth
5A	Rods and oval shaped bodies in equal proportions, prominent fat globules $2{\cdot}61$ $\mu \times 1{\cdot}41\mu$, very tough growth
6A	Rods with fat globules, the latter not so prominent $2{\cdot}18$ $\mu \times 1{\cdot}39$ μ, moderately tough growth
7A	Cells predominantly rod shaped with two fat globules at the two ends, cells with one fat globule comparatively few, when one fat globule was present, cells appeared to have a tapering end $2{\cdot}45$ $\mu \times 1{\cdot}41$ μ, very tough growth
12A	Small and comparatively bigger rods, the former comparatively more abundant, rods usually with two fatty bodies but those with one are also present, $2{\cdot}12$ $\mu \times 1{\cdot}60$ μ, moderately tough growth
15A	Rods and oval shaped cells in equal proportions, rods with two fatty bodies $2{\cdot}18$ $\mu \times 1{\cdot}36$ μ, tough growth
16A	Rods and oval cells, cells with one fat globule comparatively more abundant, $2{\cdot}45$ $\mu \times 1{\cdot}39$ μ, moderately tough growth
2WB	Rods and oval cells in equal proportion, rods with two fat globules and sometimes with three $2{\cdot}23$ $\mu \times 1{\cdot}41$ μ, moderately tough growth
3WB	Rods and oval cells, fat globules conspicuously smaller, $2{\cdot}50$ $\mu \times 1{\cdot}39$ μ, moderately tough growth
4WB	Predominantly oval shaped cells with one conspicuous fat globule, very few rods, $2{\cdot}58$ $\mu \times 1{\cdot}39$ μ, very tough growth
2B	Rods and oval cells, oval ones containing quite prominent fat globules, $2{\cdot}48$ $\mu \times 1{\cdot}39$ μ, moderately tough growth
3B	Rods and oval cells, former more plentiful than the latter, some rods with three fat globules, $2{\cdot}61$ $\mu \times 1{\cdot}41$ μ, very tough growth
1K	Rods and oval cells with fat globules varying in size, $2{\cdot}34$ $\mu \times 1{\cdot}36$ μ, very tough growth
8K	Rods and oval cells, with more or less regular shape, $2{\cdot}26$ $\mu \times 1{\cdot}36$ μ, moderately tough growth
9K	Rods and oval cells, rods more numerous than the oval bodies, large variation in size, $2{\cdot}48$ $\mu \times 1{\cdot}36$ μ, very tough growth
10K	Rods and oval cells, fat globules in the latter were much larger than those in the rods, $2{\cdot}45$ $\mu \times 1{\cdot}39$ μ, very tough growth
1M	Rods and oval cells, fat globules quite prominent, $2{\cdot}6$ $\mu \times 1{\cdot}39$ μ, very tough growth
6M	Rods and oval cells, large variation in the size of the rods, fat in the oval bodies more distinct than those in the rods, $2{\cdot}54$ $\mu \times 1{\cdot}36$ μ, very tough growth
1By	Rods and oval cells, fat globules very prominent portion of the cytoplasmic mass, large variation in the size of the fat globules, cells having two fat globules looked like diplococci under low magnification, $2{\cdot}60$ $\mu \times 1{\cdot}78$ μ, very tough growth

N.B. The measurements are averages of five independent determinations.

The cultural characteristics of the strains are given in Table III.

TABLE III. CULTURAL CHARACTERISTICS OF *BEIJERINCKIA* SPP. ISOLATED FROM INDIAN SOILS

(Temperatures of incubation 32°C; age 10 days)

Habitat	Derx's glucose agar colonies	Agar stroke	Potato
2A	Circular (diameter 1 cm. or less), smooth entire convex or dull white	Abundant growth, smooth, highly raised, glistening, tough	Moist, poor, yellowish white growth, no hydrolysis of starch
4A	Circular, smooth, entire low convex, opaque white	Abundant growth, smooth, highly raised, glistening, tough	Moist, poor, yellowish white, no hydrolysis of starch
5A	Circular (less than $\frac{3}{4}$ cm.), smooth, entire highly convex, opaque white	Abundant growth, wrinkled, glistening tough	White abundant tough growth, no hydrolysis of starch, acidic
6A	Circular, smooth, entire convex, opaque white	Abundant growth, smooth and highly raised, glistening, tough	Moist, poor whitish growth no hydrolysis of starch, acidic
7A	Circular, smooth, entire highly raised	Abundant growth, wrinkled, glistening, tough	Moist, poor white growth, no hydrolysis of starch, acidic
12A	Circular, smooth, entire convex, opaque white	Abundant, growth smooth and highly raised, glistening, tough	Moist, dirty white growth, no hydrolysis of starch, acidic
15A	Circular, smooth, entire convex, opaque white	Abundant growth, smooth and higlhy raised, glistening, tough	Moist, dirty white growth, no hydrolysis of starch, acidic
16A	Circular, smooth, entire convex, opaque white	Abundant growth, smooth and highly raised glistening, tough	Moist, slightly rough, tough white growth, no-hydrolysis of starch, acidic
2WB	Circular, smooth, entire pulvinate, opaque, white	Abundant growth, wrinkled but glistening, tough	Moist, appreciable growth, no hydrolysis of starch, acidic
3WB	Circular (less than $\frac{3}{4}$ cm. diameter), smooth entire convex, opaque white	Abundant growth, smooth and highly raised, glistening, tough	Moist, yellowish white, poor growth, no hydrolysis of starch
4WB	Circular (less than 1 cm.), smooth, entire umbonate, opaque white	Abundant growth, wrinkled, glistening, tough	Moist, tough, yellowish white growth, no hydrolysis of starch
2B	Circular, smooth, entire convex, opaque white	Abundant growth, wrinkled but glistening, tough	Moist, yellowish white growth, no hydrolysis of starch, acidic
3B	Circular, smooth, entire pulvinate, opaque and dull white	Abundant growth, wrinkled, glistening, tough	Moist, poor yellowish white growth, no hydrolysis of starch
1K	Circular (less than $\frac{1}{2}$ cm.) smooth, entire convex, opaque white	Abundant growth, smooth and highly raised, glistening, tough	Moist, poor growth, no hydrolysis of starch, acidic

TABLE III. CULTURAL CHARACTERISTICS OF *BEIJERINCKIA* SPP. ISOLATED FROM INDIAN SOILS

(Temperatures of incubation 32°C; age 10 days)

Habitat	Derx's glucose agar colonies	Agar stroke	Potato
8K	Circular, smooth, entire convex, opaque white	Abundant growth, smooth and highly raised, glistening tough	Good brownish yellow growth, no hydrolysis of starch, acidic
9K	Circular, smooth, entire highly convex, opaque white	Abundant growth, wrinkled but glistening, tough	Good yellowish white, moist growth, no hydrolysis of starch, acidic
10K	Circular, smooth, entire pulvinate, opaque, white	Abundant growth, wrinkled but glistening, tough	Abundant, tough, white rough growth, no hydrolysis of starch, acidic
1M	Circular, smooth, entire highly convex, opaque white	Abundant growth, wrinkled but glistening, tough	Poor yellowish white growth no hydrolysis of starch, acidic
6M	Circular, smooth, entire highly convex, opaque white	Abundant growth, wrinkled but glistening, tough	Good, moist yellowish white growth, no hydrolysis of starch
1By	Circular, smooth, entire umbonate, opaque white	Abundant growth, wrinkled but glistening, tough	Good, pale yellow moist growth, no hydrolysis of starch, acidic

It can be observed from Table III that two main types of growth on agar could be observed—smooth and wrinkled. The biochemical characteristics of the cultures of *Beijerinckia* spp. have been given in Table IV. The strains reduced nitrate to nitrite and none of them could liquefy gelatin.

TABLE IV. THE BIOCHEMICAL CHARACTERISTICS OF *BEIJERINCKIA* SPP. ISOLATED FROM INDIAN SOILS

(Observations relate to 15 days' incubation)

	2A	4A	5A	6A	7A	12A	15A	16A
Fructose	++RA	+A	++PA	++A	++RA	+A	++A	+RA
Arabinose	+A	+A	++RA	+A	+++PA	+A	+A	+A
Glucose	++RA	+++RA	+++PA	++RA	+++PA	++RA	++RA	+++PA
Galactose	++PA	++A	+++PA	++A	++PA	++A	++A	++A
Sucrose	+++PA	+++PA	+++PA	+++RA		++PA	+++PA	+++PA
Lactose	+SA	+SA	+A	+A		+SA	+SA	+A
Starch	+A	+A	+++A	+A		+A	+A	+A
Glycogen	++A	++A	++A	++A		+A	++A	+++A
Salicin	+SA	+SA	+SA	+SA	+SA	+SA	+SA	+SA
Mannitol	+A	±A	+RA	+A	+A	+A	+A	+A
Glycerol			±					
Nutrient broth	+ Scant S	++ Scant S	++ Abundant S	++ Scant S	++ Abundant S	+ Scant S	++ Scant S	++ Abundant S
Litmus milk	Pinkish	Pinkish	No change	Slightly reduced	Deep chocolate	Pinkish	Slightly reduced	No change

TABLE IV. THE BIOCHEMICAL CHARACTERISTICS OF *BEIJERINCKIA* SPP. ISOLATED FROM INDIAN SOILS

(Observation relate to 15 days' incubation)

	2WB	3WB	4WB	2B	3B	1K	8K	9K
Fructose	++A	++PA	++RA	+A	+++PA	+A	++PA	++RA
Arabinose	++A	+A	++PA	+A	++PA	+A	++PA	++PA
Glucose	+++PA	+++PA	+++PA	++PA	+++PA	++PA	+++PA	+++PA
Galactose	+++PA	++A	+++PA	++A	+++PA	+A	+++RA	+++PA
Sucrose	+++PA	++RA	+++PA	+++PA	+++PA	+++PA	+++PA	+++PA
Lactose	+++PA	+SA	+SA	+SA	+SA	+SA	+SA	+SA
Starch	+SA	+A	++RA	+A	+++PA	+A	++A	++A
Glycogen	++A	++A	+++A	+A	+++A	+++A	+++A	+++A
Salicin	+SA	+SA	+SA	+SA	+SA	+SA	+SA	+SA
Mannitol	+A	+A	++PA	+A	++RA	+A	++RA	+PA
Glycerol	±	±	±		±		±	
Nutrient broth	++ Abundant S	++ Abundant S	++ Abundant S	± Scant S	++ Abundant S	+ Scant S	++ Abundant S	++ Abundant S
Litmus milk	No change	Slightly reduced	Deep chocolate	Pinkish	No change	Pinkish	Reduced	No change

	10K	1M	6M	1By
Fructose	+++PA	+++PA	+++PA	+++PA
Arabinose	+PA	++PA	++PA	++PA
Glucose	+++PA	+++PA	+++PA	+++PA
Galactose	+++PA	+++PA	+++PA	+++PA
Sucrose	+++PA	+++PA	+++PA	+++PA
Lactose	+SA	+SA	+SA	+SA
Starch	+++PA	+++PA	+++PA	++A
Glycogen	+++PA	++RA	+++PA	+++PA
Salicin	+SA	+SA	+SA	
Manniton	+PA	++PA	++PA	++P
Glycerol	±	—	—	±
Nutrient broth	+ Abundant S	+ Abundant S	+ Abundant S	+ Abundant S
Litmus milk	Deep chocolate	No change	No change	Curdled, reduced

A = Acid
SA = Slightly acid
P = Pellicle
R = Ring
S = Sediment

— =No growth
\+ =Slight growth
++=Good growth
++=Excellent growth
± =Doubtful growth

The nitrogen fixing capacities of the strains of *Beijerinckia* have been given in the Table V.

TABLE V. NITROGEN FIXING CAPACITIES OF BEIJERINCKIA ISOLATED FROM SOME INDIAN SOILS

Habitat	Nitrogen fixed in mg. per gm. of glucose
2A	10·27 (10·36, 9·52, 10·92)
4A	9·52 (10·64, 12·32, 5·60)
5A	10·83 (11·48, 10·08, 10·92)
6A	8·31 (8·68, 8·40, 7·84)
7A	9·05 (8·12, 9·52, 9·52)
12A	9·61 (8·12, 9·52, 11·20)
15A	11·55 (10·64, 10·36, 10·64)
16A	11·29 (10·36, 12·04, 11·48)
2WB	11·57 (11·48, 10·92, 11·32)
3WB	8·77 (7·00, 10·36, 8·96)
4WB	10·73 (11·20, 10·92, 10·08)
2B	7·75 (7·00, 9·24, 7·00)
3B	8·87 (10·92, 5·88, 9·80)
1K	10·27 (9·24, 10·36, 11·20)
8K	9·83 (10·36, 8·40, 10·72)
9K	7·28 (5·88, 7·00, 8·96)
10K	7·75 (6·72, 8·96, 7·56)
1M	6·72 (7·84, 5·88, 6·44)
6M	5·97 (5·60, 6·16, 6·16)
1By	9·24 (10·36, 10·36, 7·00)

DISCUSSION

Distribution of Beijerinckia in Indian soils: Tchan discussed briefly the distribution of *Beijerinckia* spp. in soils of the different parts of the world. His survey of Australian soils showed that *Beijerinckia* occurs exclusively in soils of regions situated to the North of 17-18° southern latitude. The organisms of Altson, Starkey and Derx all occurred in the soils of the tropical regions. Kauffmann and Toussaint's organism *Azotobacter* (now *Beijerinckia*) *lacticogenes* was isolated from an acid forest soil of the Ivory Coast situated at northern latitude 3-10°. Isolation of strains of *Beijerinckia* from Tananarive of Madagaskar (20° southern latitude) seems to confirm Tchan's hypothesis that *Beijerinckia* spp. is confined to soils of the tropical regions. Additional confirmation of this view seems to have come from Kluyver and Becking's inability to find *Beijerinckia*

in soils of Europe and isolation of strains of *Beijerinckia* in Indonesian acid soils and in tropical soils of South America. The same authors have expressed that it is possible to connect the extreme poverty in calcium of the natural surroundings of *Beijerinckia* with Jensen's findings that these organisms, in contrast to what holds for *Azotobacter* spp. do not need calcium for their development. They have surmised that *Beijerinckia* spp. prevails in laterites and lateritic formations which explain why they have been mostly isolated so far from tropical soils.

Kluyver and Becking consider that many of the red earths which now occupy large areas of the earth's surface should be regarded as fossil and as much are met within areas which at present, have a moderate climate. Influence of the nature of the soil on the presence of *Beijerinckia* spp. appeared so logical to them that they predicted that the organism may as well be found in such soils outside the tropics. The first report of the occurrence of *Beijerinckia* outside the tropics is due to Suto who has isolated a nitrogen fixing organism which seems to be a variant of *Azotobacter* (now *Beijerinckia*) *indicum* from an acid volcanic soil at Sendai, Japan (latitude 38°N).

During the present investigation, majority of the strains of *Beijerinckia* has been isolated from soils outside the latitude 20°N. It can also be seen that five out of 20 soils from where *Beijerinckia* could be isolated are within 20° N or only 25 per cent of the soils where *Beijerinckia* spp. is observed is within the tropics. The occurrence of *Beijerinckia* spp. outside the tropics is, therefore, not as rare as suggested by Kluyver and Becking's findings.

It can also be seen that neither the acidity of the soil nor the extreme poverty of calcium can be the cause of occurrence of *Beijerinckia* spp. Out of 16 soils from Assam, with pH values ranging from 4·2 to 5·9 and with HCl soluble CaO ranging from ·056 to 0·336 per cent, *Beijerinckia* spp. occurs in only half the number of soils; the organism could not be detected in the other soils. The same is true of soils from even the same locality, Siliguri, West Bengal. The organism is absent in 1WB while the other three soils show its presence. A very interesting fact is the complete absence of *Beijerinckia* spp. in the soils of Tripura. Out of six soils from Bihar, the organism occurs only in two and in five soils out of 11 from Kerala. Two soils out of six Mysore soils have been observed to contain the organism. The reasons why *Beijerinckia* spp. occurs in some soils and why it does not occur in certain others are not clear. It can also be seen, though not very conclusively that the soils where *Beijerinckia* spp. has been observed all are not laterites nor can they be called lateritic formations. They have been found in soils which can be included in alluvial and acid forest soil types. Some of them are swamps where paddy is grown.

Statistical analysis of the data of the various chemical and mechanical constituents of the soil showing presence or absence of *Beijerinckia* spp. shows that the differences between the constituents of these two groups of soils are not significant. This shows that excess or deficit of any particular constituent of the soil is not responsible for the presence or absence of the organism. This confirms the findings of Tchan.

It is possible that occurrence of the organism has something to do with vegetation. This view is supported by the later surmise of Derx who attributed the occurrence of the organism in the tropics to a possible association with some specific genera of plants, like the non-nodulating legumes and suggested that *Beijerinckia* was a facultative

symbiont which had not lost the capacity to fix nitrogen outside the plant. Recent report of the occurrence of a large number of cells of *Beijerinckia* in the leaves of trees and epiphytes in the tropical forest of Indonesia (Ruinen, *loc. cit.*) appears to support this view.

The soils used during the present investigation have been collected mostly from paddy fields under similar climatic influences in several states. As *Beijerinckia* has been observed to be present in some soils and absent in others, it is doubtful, if nature of vegetation alone can explain the presence of the organism in particular soils and absence in others.

The nature of the strains of Beijerinckia isolated from Indian soils: The streaks on agar plates of the organism seem to be characteristically those of *Beijerinckia* shown by tough growth under acid conditions when that of most bacteria are eliminated. The colonies in agar are invariably circular, smooth with an edge which can be called entire and with opaque white or fulvous in appearance. Some variations in size of the colonies in the case of different strains are observed. Three types of elevation of growth can be seen, viz., (i) convex (15 strains), (ii) pulvinate (three strains) and (iii) umbonate (two strains). In agar slopes, however, only two distinct forms of growth can be seen. These are smooth and raised and wrinkled and raised. The growth in agar is invariably tough; of all the strains isolated, six strains show poor growth on potato and these generally give reaction which is alkaline to methyl red. The remaining 14 show good growth on potato and exhibit reaction which is acid to methyl red. The pigmentation in the case of poor growth is generally yellowish white, while in others it varies from white to yellow and brown.

The strains are seen to be characterised by a good deal of similarities. Not much difference in the size of the strains can be discovered. They vary from 2·12 to 2·16 μ in length and from 1·36 to 1·78 μ in breadth. The strains have been seen to be without capsule. They do not form spores and are all gram negative. The strains all reduce nitrates to nitrites. No strain liquefies gelatine even on prolonged incubation. Glucose is freely utilised by the strains. Salicin is utilised only with difficulty. The strains grow well in sucrose and the growth is usually characterised by formation of an almost continuous mass of slimy growth at the surface of the liquid. Utilisation of glycerol by the strains has not been established beyond doubt even in the case of a single strain. Five of them have been seen to be unable to show growth in lactose while 15 others do so rather poorly. No gas is formed in any of the sugars on growth of the strains in the same.

The strains also show some dissimilarities in characteristics. Seven strains show only scant growth in nutrient broth as can be observed from the small amount of cellular and polysaccharide sediment in the liquid. The remaining 13 give copious sediment in nutrient broth culture. Five strains utilise fructose with difficulty; the 15 others show good growth in medium containing fructose. Half the strains exhibit poor growth in arabinose while the remaining utilise the sugar more comfortably. Only one strain of the organism isolated from Kerala is unable to grow well in galactose. Others grow more or less freely in presence of the sugar. Starch is not utilised at all by the three strains, poorly so by seven strains. Rest are active utilisers of starch. Fourteen strains show poor growth in mannitol, six others grow well in alcohol.

Most of the strains utilise glycogen but in the case of two strains, one from Assam and another from Bihar, glycogen is used rather poorly. A lot of dissimilarities is exhibited by the strains in case of litmus milk.

There are five species of *Beijerinckia* known uptil now and it appears from the characteristics of the isolates that except for minor differences in characteristics, in all probability, the strains belong to one species and one variety, viz., *Beijerinckia indicum* and *B. indicum* var. *alba*. The nitrogen fixing capacity of the strains vary from 5·97 to 11·57 mg. per gm. of glucose. These are of the same order as has been observed in the case of these species. The pigment forming species *B. mobile* (amber brown) and *B. derxi* (greenish yellow fluorescent) and slime free *B. lacticogenes* have not been met with during the present investigation. *Azotobacter* (*Beijerinckia indicum*) was first isolated from paddy areas with acid reaction. It is quite probable that since most of the soils under the present investigation were collected from paddy areas, the particular species of *Beijerinckia* prevailed while other species have not been met with. They may be present in soils with different type of vegetation and under different climatic and cultural conditions.

SUMMARY AND CONCLUSION

During examination of some 50 acid soils from Assam, Tripura, West Bengal, Bihar, Kerala, Mysore and Bombay, it was observed that *Beijerinckia* spp. occurred in 40 per cent of the soils.

Contrary to certain findings, *Beijerinckia* spp. was found to occur as well outside the latitude 20° north as inside it and in soils, other than laterites and lateritic formations.

The presence of *Beijerinckia* spp. in soils could not be attributed to the occurrence of any particular soil constituent in excess or to any type of particular vegetation. The latter probably determined the species that predominated when the organism was found to be present.

The nitrogen fixing capacity of the strains of *Beijerinckia* varied from 5·97 to 11·57 mg. per gm. of glucose during the period of one month.

From the morphological, cultural and biochemical characteristics of the pure cultures of the isolates it could be surmised that they were different strains of only one species and one variety of the genus *Beijerinckia*, i. e., *B. indicum* and *B. indicum* var. *alba*.

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APPENDIX I

Composition of the soils

(Constituents expressed as per cent on moisture-free basis)

Soil No.	pH	Mechanical composition			Organic carbon	Organic nitrogen	HCl soluble	
		Sands	Silt	Clay			CaO	P_2O_5
1A	4·6	83·30	12·44	4·26	1·52	0·101	0·084	0·09
2A	5·5	46·26	57·46	2·28	0·96	0·140	0·224	0·10
3A	4·5	79·26	15·88	4·86	0·88	0·090	0·056	0·11
4A	4·5	89·16	9·58	1·26	1·91	0·103	0·168	0·13
5A	5·0	50·22	36·24	13·54	1·31	0·122	0·168	0·19
6A	4·4	92·44	6·14	1·42	1·30	0·139	0·224	0·13
7A	4·2	69·06	27·74	8·20	1·98	0·159	0·168	0·13
8A	4·4	73·76	20·58	5·66	0·96	0·151	0·112	0·11
9A	4·4	60·88	34·06	5·06	0·77	0·112	0·112	0·15
10A	4·2	56·20	38·10	5·70	1·28	0·156	0·140	0·14
11A	5·5	68·72	27·50	3·78	0·46	0·074	0·168	0·11
12A	5·8	86·68	10·46	1·86	0·55	0·062	0·182	0·15
13A	6·3	89·74	10·14	0·12	0·62	0·046	0·336	0·18
14A	5·5	30·30	50·54	19·16	0·62	0·095	0·140	0·17
15A	5·9	65·76	33·60	0·64	0·87	0·139	0·280	0·14
16A	4·7	96·70	3·06	0·24	3·18	0·315	0·056	0·15
1WB	5·1	47·70	44·60	7·70	0·90	0·095	0·112	0·15
2WB	4·6	..	..	..	0·90	0·095	0·056	0·28
3WB	5·3	80·96	10·50	8·54	1·98	0·215	0·224	0·28
4WB	5·2	32·02	37·04	10·94	1·01	0·172	0·266	0·17
1T	5·8	52·00	27·06	20·94	0·77	0·110	0·196	0·13
3T	5·5	54·06	27·24	18·70	1·08	0·112	0·252	0·27
4T	5·0	53·28	32·74	13·98	0·83	0·115	0·168	0·18
5T	4·7	77·06	22·42	0·52	2·08	0·153	0·084	0·08
6T	5·7	77·78	22·16	0·08	1·28	0·148	0·182	0·11
1B	5·5	57·68	22·90	25·42	0·74	0·082	0·280	0·11
2B	5·9	50·94	26·02	23·04	0·64	0·085	0·392	0·14

APPENDIX I

Composition of the soils

(Constituents expressed as per cent on moisture-free basis)

Soil No.	pH	Mechanical composition			Organic carbon	Organic nitrogen	HCl soluble	
		Sands	Silt	Clay			CaO	P_2O_5
3B	6·0	57·54	24·00	18·46	0·45	0·048	0·280	0·10
4B	7·3	54·04	21·32	24·64	0·49	0·056	0·392	0·09
5B	5·0	63·88	23·58	12·54	0·64	0·073	0·224	0·11
6B	5·9	49·62	30·04	20·34	0·64	0·097	0·392	0·13
1K	5·8	68·44	20·62	10·94	0·77	0·117	0·280	0·46
2K	6·4	..	..	..	0·64	0·095	0·084	0·10
3K	5·9	69·10	22·46	8·44	1·78	0·202	0·196	0·43
4K	5·4	78·28	19·88	1·84	1·62	0·173	0·168	0·38
5K	6·1	86·14	9·78	4·08	0·99	0·184	0·294	0·34
6K	6·1	83·56	11·34	5·10	0·83	0·083	0·084	0·16
7K	6·3	81·04	11·54	7·38	0·64	0·075	0·084	0·10
8K	6·0	67·50	20·08	12·42	1·12	0·139	0·210	0·28
9K	5·4	82·58	13·84	3·58	0·77	0·036	0·168	0·42
10K	5·5	80·16	10·12	9·72	0·77	0·102	0·252	0·37
11K	4·8	79·28	14·70	6·02	2·84	0·308	0·112	0·33
1M	5·1	47·70	38·24	14·06	2·30	0·247	0·182	0·17
2M	5·2	43·48	41·94	14·58	1·49	0·196	0·224	0·25
3M	4·7	69·38	10·22	20·40	1·25	0·139	0·112	0·25
4M	5·4	68·60	22·08	9·32	2·62	0·252	0·140	0·14
5M	5·1	67·90	24·70	7·40	1·74	0·179	0·112	0·40
6M	6·4	83·44	12·04	4·52	0·58	0·070	0·322	0·16
1By	5·8	32·46	22·30	45·24	1·52	0·164	0·504	0·17

SYNTHETIC EXPERIMENTS IN TERPENE SERIES

1—LONGIFOLYL THIOCYANO ACETATE, AN INSECTICIDE

SAT BIR, B. G. CHATTERJEE AND K. C. GULATI

Received: January 2, 1957

Sesquiterpenes (mostly longifolene) are present in Indian turpentine oil ex *Pinus longifolia* to the extent of about 20 per cent (Duponte, 1924) The presence of longifolene, has also been reported in several other essential oils.

On the basis of oxidation degradation studies, Simonsen *et al.* (1923) suggested two possible structures (I) and (II) and more recently Naffa and Ourisson (1953) in the light of physico-chemical evidence have given to the sesquiterpene the structure (III). According to any one of these structures, longifolene contains an exocyclic double bond and according to (III) the double bond is situated so as to produce a methylene grouping instead of the vinyl grouping as suggested by Simonsen. This exocyclic methylene grouping should be an important seat of reactivity in the molecule and thus render longifolene a useful chemical raw material.

The sesquiterpene because of its physico-chemical properties such as high boiling point, high specific gravity and high rates of resinification and polymerization, has to be removed from the oil for the production of satisfactory grades of turpentine. There has been little use made of the terpene so far and as such it is the waste product of rosin and turpentine industry.

The present communication relates to the reparation of esters by the combinations of longifolene with acetic acid and chloracetic acid (addition) in presence of inorganic acid as catalysts (Sathon, 1905), and hydrolysis of the esters, preparation of the chloroacetate of the alcohol through azeotropic distillation with benzene and thiocyanation of chloracetates to corresponding thiocyano acetates (Chatterjee and Gulati, 1952). For convenience sake, the compounds obtained are referred to as longifolyl derivatives.

The percentage conversion to longifolyl monochloracetate as obtained in the initial experiment by one step conversion of longifolene by reaction with monochloracetic acid was low (14·45 per cent). With a view to improve upon the low yield of monochloracetate, attempts were made to standardise conditions using acetic acid, which is more readily available than monochloracetic acid. This also provided an alternate route for the preparation of the monochloracetate, viz. the longifolyl alcohol and incidentally yielding a product of higher purity.

From the above, it will be seen that yields of longifolyl esters by the interaction of longifolene with organic acids has been about 21·25 per cent, whereas Sukh Dev and Nayak (1954) obtained an approximate yield of 30 per cent of ester while carrying out the esterification with acetic acid in presence of sulphuric acid in dioxane; saponification of the ester having led to a mixture of alcohols.

The unreacted hydro-carbon and the alcohol obtained on hydrolysis of longifolyl acetate have shown some interesting physico-chemical properties and will form subject of a separate communication.

According to the preliminary tests, as carried out on longifolyl thiocyanoacetate against aphids collected from toria crop, the compound gave encouraging results as a contact toxicant. Consequently, the compound was tested at length against safflower aphids, *Microsiphum saliditginis* and the lethal dose was found to be 1·3 per cent in case of the material with 56·8 per cent purity.

EXPERIMENTAL PROCEDURE

Longifolene, used in the investigation was obtained by the fractional distillation of residual turpentine oil (commonly known as quality III oil) obtained from Government Rosin and Turpentine Factory, Clutterbuckganj, Bareilly, (U.P.) and had b.p., 120-5°C/19 mm. (250-55°C/750 mm.); d^{30}_4, 0·9237; $^nD^{30}$, 1·4939 and $[\alpha]\ D^{30}+31·65°$.

In an initial trial on the esterification of longifolene with monochloracetic acid, longifolene, 25 gm. (0·12 mole) was mixed with the chloracetic acid 13 gm. (0·14 mole) and sulphuric acid 0·25 gm. in a three necked flask, fitted with stirrer and thermometer. The mixture was heated on water bath at 50-60 °C and stirred for 12 hours. The reaction mixture was washed thoroughly with water and the oily layer dried over anhydrous potassium carbonate (filtered); the product was found to contain 1·72 per cent chlorine (estimation by Stepanov's methods) calculated for $C_{17}\ H_{27}\ O_2\ Cl$, 11·89 per cent. The percentage purity of longifolyl monochloracetate was 4·45 per cent.

Further experiments were conducted using acetic acid and factors such as catalyst, temperature, period of reaction and mode of addition of longifolene were studied. The percentage of longifolyl acetate in the crude product was calculated on the basis of its ester value (calculated for longifolyl acetate, 212·12).

TABLE I. COMBINATION OF LONGIFOLENE WITH ACETIC ACID—EFFECT OF VARIOUS CATALYSTS

Catalyst	Temperature of reaction	Ester value	Percentage purity
0·5 per cent H_2SO_4	75·80°C	30·8	14·5
2·0 per cent H_2SO_4	75·80°C	52·2	24·6
8·0 per cent H_2SO_4	75·80°C	24·3	11·4
2·0 per cent (50 per cent HNO_3)	75·80°C	46·2	21·8
5 per cent $ZnCl_2$	50·60°C	19·2	9·0

Optimum concentration of the catalyst being 2·0 per cent, small amount of moisture did not affect esterification adversely, thus obviating the necessity of employing anhydrous conditions for carrying out reaction.

TABLE II. EFFECT OF VARYING THE TEMPERATURE OF REACTION, USING 2 PER CENT SULPHURIC ACID AS CATALYST

Temperature	Duration of reaction (hours)	Ester value	Percentage purity
50–60	8	36·0	17·0
60–70	8	42·4	20·0
70–80	8	52·5	24·8
90–95	8	52·2	24·8
95–100	8	35·8	16·9
120–130	8	22·0	12·7

Higher temperature gave a darker and more viscous product of lower purity, presumably due to the polymerization of the terpene.

It was also found that dropwise addition of longifolene to the mixture of acetic acid and sulphuric acid gave a product of slightly higher purity.

In the light of the above experiment, acetic acid 30 gm. (0·5 mole), sulphuric acid 1 gm. (two per cent on longifolene), were mixed in a three-necked flask fitted with thermometer, stirrer and dropping funnel. The mixture was heated on water bath at 70-80°C. Longifolene 51 gm. (0·25 mol.) was added dropwise in course of two hours and the reaction was carried for another six hours. The reaction mixture after washing with water, drying, etc. was found to have an ester value 54·0., percentage purity 25·5 per cent. The product was reddish-brown in colour and the yield 49 gm.

Crude longifolyl acetate, 100 gm. was hydrolysed with 600 cc. of 10 per cent. alcoholic caustic potash under reflux for four hours. Ethyl alcohol was distilled off on water bath and the residue washed with water, and dried over anhydrous sodium sulphate, yield 74 gm., OH, 1·83 per cent (Zerevitinoffs method), corresponding to 23·9 per cent purity. Calculated for C_{15} H_{25} OH, 7·66 per cent 730 gm. of the crude product was fractionated under reduced pressure, using ordinary laboratory equipments.

TABLE III. FRACTIONATION OF CRUDE LONGIFOLYL ALCOHOL

Fraction °C/19 mm.	Yield (gm.)	Per cent OH	Percentage $C_{15}H_{25}OH$
Upto 90	15	12·1	149·
90–120	150	0·99	12·92
120–125	200	1·44	18·8
125–130	155	1·34	17·5
130–135	179	1·45	18·93
Residue	30	5·85	76·37

The high hydroxyl content of the fraction No. 1 was probably due to some water/ethyl alcohol present in the starting material. The residue above 135° C was a thick brown liquid with pleasant smell. The fraction Nos. 2, 3, 4 and 5 were mixed together and redistilled, but with the equipment available, no distinct cut of longifolyl alcohol could be obtained. The residue above 140°C/19 mm. (yield, 12 gm.) had–OH, 5·87 per cent corresponding to 76·6 per cent purity.

The principle of selective solubility was also used for extracting longifolyl alcohol. One hundred gm. crude material was dissolved in minimum quantity of ethyl alcohol (500 cc.) in a separating funnel. To the clear solution, 1 cc. of water was added and separated oil was collected in a graduated cylinder. The process was repeated till 80 ccs. of the oil were collected. The water and ethyl alcohol were removed from the aqueous-alcoholic portion under reduced pressure. The residue (21 gm.), boiling range, 135-155°C/19 mm., found, OH, 5·11 per cent (percentage purity 66·7).

Crude longifolyl alcohol 118 gm. (purity 66·7 per cent) as obtained according to the above procedure was fractionated. The fraction, b.p. 145—150°C/19 mm. (23 gm.) was found to have—OH, 6·9 per cent (90·1 per cent. C_{15} H_{25} OH); $^{n}D^{30}$, 1·4975); d_4^{60}*, 0·9979; [α] D^{20}, +9·618. The product when kept in the refrigerator for long time, crystallised out in long needles. However, it was not found possible to determine the melting point.

Starting with the above sample of longifolyl alcohol and chloracetic acid, it was found possible to bring about almost complete esterification of alcohol by using azeotropic distillation with benzene in Dean and Stalks apparatus. However, for the purpose of preparing longifolyl thiocyano acetate for test as insecticide, the monochloracetate was prepared by the addition of chloracetic acid across the double bond of the terpene hydro-carbon according to the following procedure.

Monochloracetic acid, 235 gm. (2·5 mol.) was fixed with 5 gm. sulphuric acid in a three-necked flask. Longifolene 255 gm. (1·25 mol) was added. The reaction was carried out as given under longifolyl acetate. Worked up the reaction mixture (yield 274 gm.), found Cl. 2·5 per cent and calculated for C_{17} H_{27} O_2 Cl, 11·89 per cent (percentage purity, 21·1).

The unreacted hydrocarbon was removed by steam distillation. The dark-brown residue left in the flask was heavier than water, found Cl., 6·66 per cent (percentage purity, 56·1).

Longifolyl thiocyanoacetate

Longifolyl monochloracetate, 90 gm. (purity 61·6 per cent.) was taken up in 200 cc. of alcohol and was mixed with ammonium thiocyanate 15 gm. in 150 cc. of alcohol. The mixture was heated on water bath at 60-65° with stirring for six hours, when ammonium chloride gradually separated out. The reaction product was filtered, alcohol removed from the filtrate, the residue was taken up in petroleum ether (40-60°) and washed with water. After the removal of petroleum ether, residue weighed

* Longifolyl alcohol was heavier than water at room temperature though the ratio of the density at 80°C to that of water at 4°C was found to be less than one.

92 gm. and found N, 2·48 per cent (Kjeldahl's method) calculated for $C_{18}H_{27}O_2NS$, 4·361 (percentage purity, 56·8).

SUMMARY

Starting from longifolene, longifolyl thiocyanoacetate of purity about 57 per cent has been prepared. The compound has shown promising properties as an insecticide against aphids, lethal dosage being 1·3 per cent. The compound with higher purity is likely to be more potent.

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SYSTEMATICS OF ORIENTAL TERMITES

VI* FULLER DESCRIPTION OF TWO SPECIES OF *ODONTOTERMES* FROM INDIA

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Zoological Survey of India, Calcutta

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Fuller descriptions of two species of the termite genus *Odontotermes* Holmgren (Insecta, Isoptera, Family Termitidae, subfamily Macrotermitinae) from peninsular India recently (1959) briefly described by us are given in this article, and are based on collections sent by Shri B. M. Kulkarni (Department of Zoology, Karnatak College, Dharwar, Mysore State), the Government Entomologist (Mysore State) Bangalore, and a collection already present in the Zoological Survey of India.

This work was financed by the Indian Council of Agricultural Research under the Termite Research Scheme (Taxonomy) which functioned previously at the Forest Research Institute, Dehra Dun, and was later transferred to the Zoological Survey of India, Calcutta, from April 1, 1957.

All type-specimens, except where otherwise stated, are deposited in the Zoological Survey of India, Calcutta.

FULLER DESCRIPTION OF SPECIES

1. *ODONTOTERMES KULKARNII* Roonwal and Chhotani.

MATERIAL

Two soldiers and several workers, in spirit, Bijapur (16°50′N. lat. and 75°47′ E. long) Mysore State, India, coll. *B. M. Kulkarni*, last week December, 1957; found under cowdung mixed with earth.

DESCRIPTION

IMAGO—Unknown.

SOLDIER (Plate I; Table I)

General: Head-capsule yellowish; antennae yellow, paler than head-capsule; labrum rust yellow; postclypeus yellowish like head-capsule; anteclypeus whitish; mandibles dark brown, darker distally; pronotum, legs and body pale yellow. Head and pronotum moderately hairy; body and legs thickly pilose. Total body-length *ca.* 5·03-5·30 mm.

Head: Head-capsule subrectangular, flat; longer than broad; sides straight, slightly coverging in front of antennae; posterior margin weakly convex. *Fontanelle:* Indistinct. *Eyes and ocelli*: Absent. *Antennae:* 16-segmented; segments 1 and 2 sparsely and others moderately pilose; segment 1 long, cylinderical; 2 cylinderical, shorter than 1; 3 subequal to or shorter than 2 and longer than 4; 4 shortest; 5-8 increasing in length and gradually becoming club-shaped in that order; 9 to the penultimate one almost subequal in length and club-shaped; last segment ovate. *Clypeus:* Divided into an ante- and a postclypeus. Anteclypeus a white narrow, semilunar strip along anterior margin of postclypeus. Postclypeus subrectangular, with a few hairs;

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not distinctly separated from frons. *Labrum:* Distal part subtriangular with the tip bluntly pointed; body with the sides subparallel; with a few long setae on tip and on body. *Mandibles:* Sabre-shaped, relatively thin and rather sharply curved inwards near the tip; shorter than head (length 0·93 *vs.* 1·50 mm.). Left mandible with a prominent tooth in the middle third, a little above the middle. Right mandible with a minute, rudimentary tooth in the middle third. *Postmentum:* Subrectangular; broadest in anterior one-fourth, whence the sides weakly narrowing posteriorly, and anteriorly converging sharply; distal margin almost straight; with a few short hairs on body; posterior margin concave with a weak median bulge.

Thorax: Pronotum: Saddle-shaped, narrower than head-capsule, much broader than long; anterior lobe upturned; anterior and posterior margins deeply incised in middle; sides converging posteriorly. *Mesonotum:* Narrower than pronotum; posterior margin substraight. *Metanotum:* Broader than pronotum; posterior margin substraight. *Legs:* Long and thin; tibial spurs 3 in forelegs and 2 each in middle and hindlegs; tarsi 4-jointed.

Abdomen: Elongated and hairy. Cerci 2-jointed, 0·10 mm. long. Styli single jointed, 0·075 mm. long.

Measurements: See Table I.

TABLE I. BODY-MEASUREMENTS (IN MM.) AND INDICES OF *ODONTOTERMES KULKARNII* Roonwal and Chhotani

Caste: Soldier

Body-parts	Range (2 specimens)	Holotype
I. GENERAL		
Total body-length *ca.*	5·03–5·30	5·30
II. HEAD		
Length of head to base of mandibles	1·50	1·50
Maximum width of head	1·20	1·20
Height of head	0·78–0·80	0·78
Head-index I (Width/Length)	0·80	0·80
Head-index II (Height/Width)	0·65–0·66	0·65
Head-index III (Height/Length)	0·52–0·53	0·52
Median length of labrum	0·30–0·35	0·30
Maximum width of labrum	0·35	0·35
Minimum length of mandibles (distal tip to upper base of outer condyle)		
(*a*) Left mandible	0·93	0·93
(*b*) Right mandible	0·93	0·93
Basal width of left mandible	0·40	0·40
Left mandibular tooth distance (Distance between distal tip and base of tooth)	0·35	0·35
Head-mandibular length index (Left mandible-length/ head-length)	0·62	0·62
Left mandibular tooth index (Tooth distance/Mandible length)	0·37	0·37
Left mandible index (Basal width / Length)	0·43	0·43
Minimum (median) length of postmentum	0·90	0·90
Maximum width of postmentum	0·53	0·53
Minimum width of postementum (waist)	0·45	0·45
Width of postmentum at anterior margin	0·38	0·38
III. THORAX		
Maximum length of pronotum	0·53	0·53
Maximum width of pronotum	0·88–0·93	0·88
Pronotum-head index (Pronotum width/Head width)	0·73–0·77	0·73

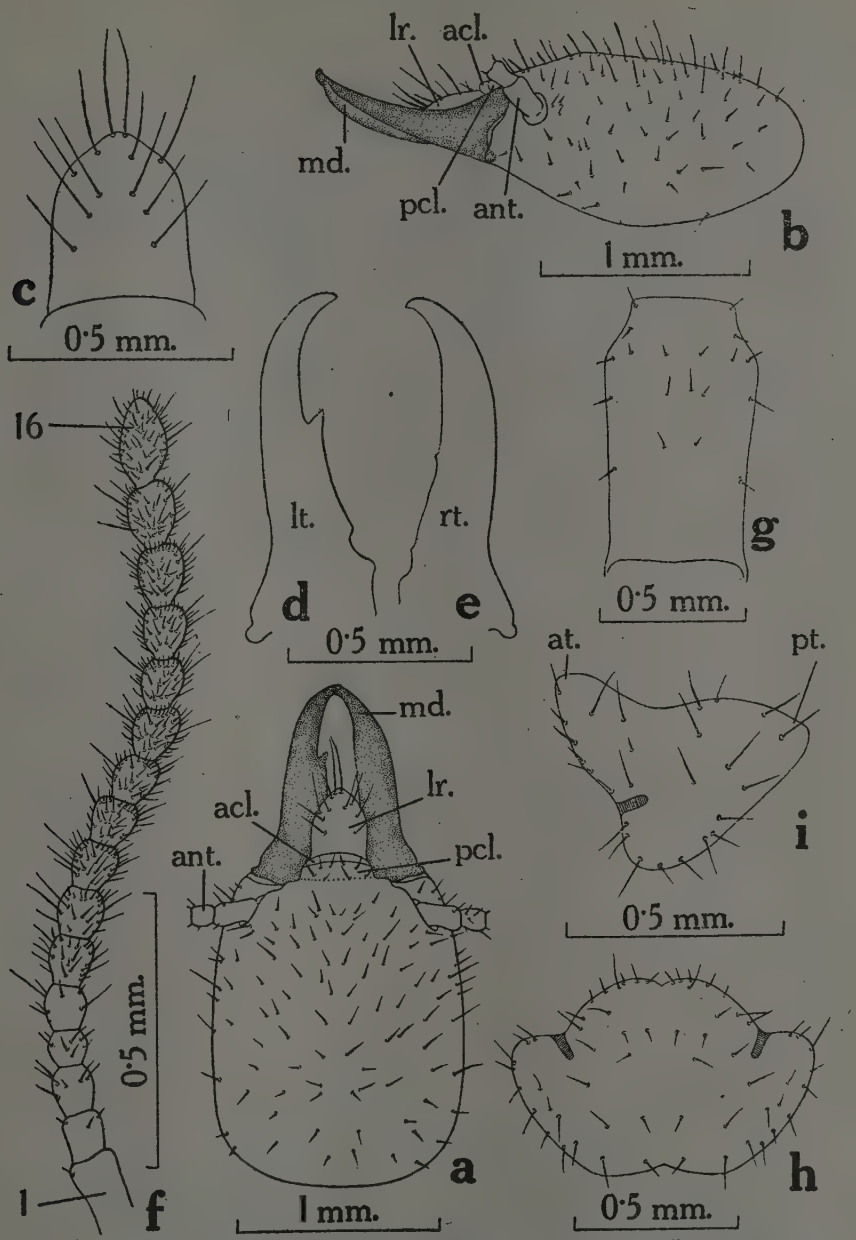

PLATE I. ODONTOTERMES KULKARNII Roonwal and Chhotani—Soldier caste

Figs. (d)—(f) from the holotype soldier and others from paratype soldier, coll. *Kulkarni*, 1957.

(a) Head, in dorsal view; (b) Head, in (left) side view; (c) Labrum, in dorsal view; (d) Left mandible, in dorsal view; (e) Ditto, right mandible; (f) Left antenna, in dorsal view. First and last (16th) segments numbered; (g) Postmentum, in ventral view; (h) Pronotum, in dorsal view (*in situ*); (i) Pronotum, in side view (*in situ*).

acl., anteclypeus; *ant.*, antenna; *at.*, anterior; *lr.*, labrum; *lt.*, left; *md.*, mandible; *pcl.*, postclypeus; *pmt.*, postmentum; *pt.*, posterior; *rt.*, right.

WORKER MAJOR (Plate II)

General: Head-capsule yellow, frons paler; labrum and clypeus yellow; antennae yellow, paler proximally; pronotum, legs and body white to dirty white. Head moderately pilose; body thickly pilose. Total body-length *ca.* 3·80-5·05 mm.

Head: Subround, flat; depressed in the region of frons; sides somewhat narrowing posteriorly; posterior margin round. *Fontannelle:* Indistinct. *Eyes and ocelli:* Absent. *Antennae:* 17- segmented; pilose, pilosity increasing distally; segment 1 longest; 2 smaller than 1 but longer than 3; 3 shortest, sometimes subequal to 5; 4 longer than either 3 or 5; 6-10 (or 11) increasing in length in that order; 10 (11)-16 subequal; last segment (17) ovate and narrower than the penultimate one. *Clypeus:* Divided into an ante- and a postclypeus. Anteclypeus narrow, trapezoidal and apilose; with a semilunar, chitinoid, yellow, median band. Postclypeus large, slightly swollen; divided into right and left halves by a median suture. *Labrum:* Subsquarish, with anterior margin rounded; with a group of setae of varying sizes on body. *Mandibles:* Subsquarish. Left mandible with an apical and 2 marginal teeth; apical finger-like; 1st marginal similar and subequal to apical; 2nd marginal very small, weak and not pointed. Right mandible also with an apical and 2 marginal teeth; apical finger-like; 1st marginal somewhat larger than apical; 2nd marginal small and not pointed.

Thorax: Pronotum: As in soldier except being a little broader relative to length; median notch in posterior margin gradual and not sharp and deep. *Legs, mesonotum and metanotum:* As in soldier.

Abdomen: Elongated or subglobular. Cerci 2 -jointed, 0·10 mm. long; Styli single jointed 0·10 mm. long.

WORKER MINOR

Resembles the worker major except for its smaller size.

Measurements (in mm.) of major and minor workers of *Odontotermes kulkarnii* Roonwal and Chhotani are given below.

	Workers major (5)	*Workers minor* (2)
Total body-length *ca.*	3·8 – 5·05	3·00 – 3·50
Head-length to lateral base of mandibles	1·28 – 1·40	0·75
Maximum head-width	1·33 – 1·50	0·95 – 1·00
Maximum length of pronotum	0·35 – 0·40	0·30 – 0·33
Maximum width of pronotum	0·70 – 0·80	0·63

(The number measured is given in brackets)

TYPE SPECIMENS: All type-specimens are deposited in National Zoological Collections at the Zoological Survey of India, Calcutta. All from a single source, *vide* 'Material' above.

Holotype: A holotype soldier, Z.S I.[1] Reg. No. 2373/H8 in spirit in a separate vial.

[1] Z.S.I. is used for Zoological Survey of India throughout this paper.

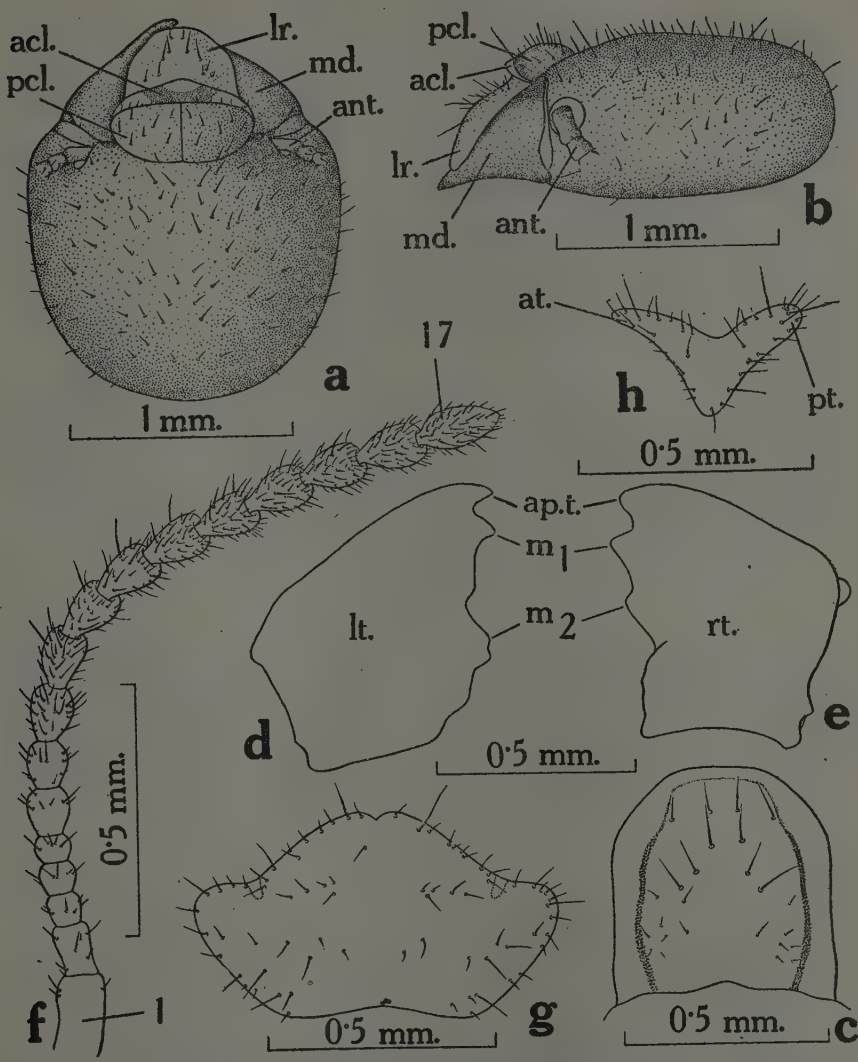

PLATE II. ODONTOTERMES KULKARNII Roonwal and Chhotani—Worker (major) caste

All figures are from the paramorphotype workers major, *Kulkarni* 1957. coll.

(a) Head, in dorsal view;
(b) Head, in side view (left);
(c) Labrum, in dorsal view (Slide No. 4.);
(d) Left mandible, in dorsal view (Slide No. 4.);
(e) Ditto, right mandible;
(f) Left antenna, in dorsal view. First and last (17th) segments numbered (Slide No. 4.);
(g) Pronotum, in dorsal view (*in situ*);
(h) Pronotum, in side view (*in situ*).

acl., anteclypeus; *ant.*, antenna; *ap.t.*, apical tooth of mandible; *at.*, anterior; *lr.*, labrum; *lt.*, left; m_1—m_2, first and second marginal teeth of mandibles; *md.*, mandible; *pcl.*, postclypeus; *pt.*, posterior; *rt.*, right.

Morphotypes: Two workers (one major and one minor) in spirit (Z.S.I. Reg. No. 2374/H8).

Paratype and Paramorphotypes: One paratype soldier and 4 paramorphotype workers in spirit (Z.S.I. Reg. No. 2375/H8) and a paramorphotype worker slide (Z.S.I. Reg. No. 2382/H8).

TYPE-LOCALITY: India, Bijapur (Mysore State), 16°50′ N. lat.; 75°47′ E. long.

DISTRIBUTION: *India:* Mysore State: Known only from the type-locality.

COMPARISION: The soldiers of *Odontotermes kulkarnii* are very close to those of *O. assmuthi* Holmgren, but differ as follows: (a) Head-capsule smaller (head-length to base of mandibles 1·50 mm. *vs.* 1·60-1·65 mm.); and (b) mandibles relatively thin and long (in *assmuthi* short and stout); head mandibular length index higher (0·62 *vs.* 0·51-0·53); index basal width of left mandible/mandible length lower (0·43 *vs.* 0.48-0·50).

The soldiers of *O. kulkarnii* are also near *O. malabaricus* Holmg. and Holmg. and *O. ceylonicus* Holmg. but can be easily differentiated from them as follows: (a) Tooth of left mandible lying above the middle point of mandible (below the middle point in *malabaricus* and in the middle in *ceylonicus*); and (b) head-capsule shorter and narrower (head-length to base of mandibles 1·50 mm. *vs.* 1·70 mm. in *malabaricus* and 1·79 in *ceylonicus*; head-width 1·20 mm. *vs.* 1·37 in *malabaricus* and 1·36 in *ceylonicus*).

2. *ODONTOTERMES METURENSIS* Roonwal and Chhotani.

MATERIAL

(i) Four soldiers and several workers, in spirit, from Hoganikal Falls, Mettur Dam (*ca.* 11°52′ N. lat.; 77°50′ E. long.), coll. *T. G. Vazirani*, February, 1952; *ex.* "a log of wood lying on ground." (ii) One soldier in spirit, from Bangalore (Mysore State), coll. *K. S.S. Sastry* (his. No. 2), June, 1956; *ex.* "the root region of *Poinciana regia* Bojer." (iii) One soldier and one worker in spirit, from Bangalore (Mysore State), coll. *K. S. S. Sastry* (his. No. 23), July, 1956.

DESCRIPTION

IMAGO. Unknown.

SOLDIER (Plate III; and Table II)

General: Head-capsule and labrum yellow to brownish yellow; mandibles dark brown, black distally; antennae, pronotum, legs and body pale yellow. Head sparsely pilose; pronotum and body comparatively densely pilose. Total body-length *ca.* 6·30-7·35 mm.

Head: Flat, subrectangular; slightly converging in front and behind; posterior margin convex; frons sloping in front. *Fontanelle:* Indistinct. *Eyes and ocelli:* Absent. *Antennae:* With 16 segments; pilose; segments 1 and 2 with a few hairs; in others pilosity gradually increasing with the distal segments; segment 1 longest, cylindrical; 2 about half of 1, cylindrical; 3 shorter than 2 and longer than 4; 4 shortest; 5-10 gradually increasing in length in that order and becoming club-shaped; 11-15 club-shaped, sub-equal and slightly smaller than 10; 16 (terminal) ovate, a little longer than the penultimate one. *Clypeus:* Divided into an ante- and a postclypeus. Anteclypeus a white, thin,

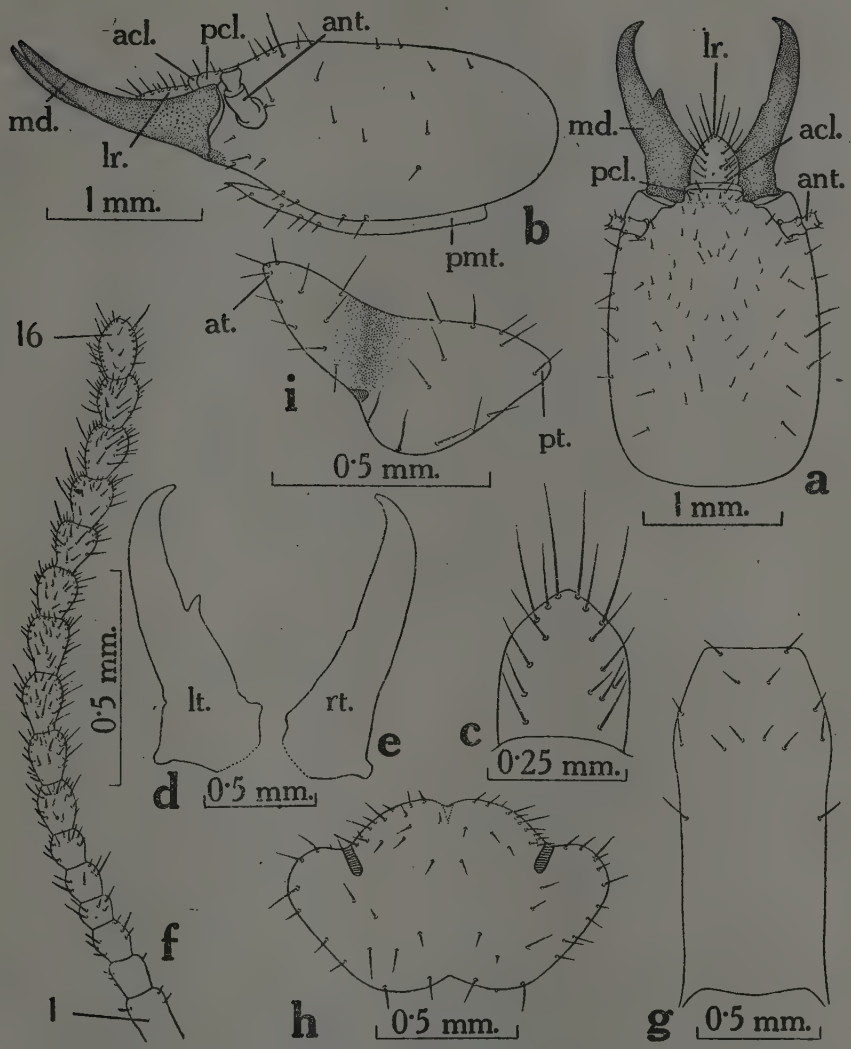

PLATE III. ODONTOTERMES METURENSIS Roonwal and Chhotani—Soldier caste

All figures are from the holotype soldier from Hoganikal Falls, Mettur Dam (Madras) coll. *Vazirani*, 1952.

(a) Head, in dorsal view;
(b) Head, in side view (left);
(c) Labrum, in dorsal view;
(d) Left mandible, in dorsal view;
(e) Ditto, right mandible;
(f) Left antenna, in dorsal view. First and last (16th) segments numbered;
(g) Postmentum, in ventral view;
(h) Pronotum, in dorsal view (*in situ*);
(i) Pronotum, in side view (*in situ*).

acl., anteclypeus; *ant.*, antenna; *at.*, anterior; *lr.*, labrum; *lt.*, left; *md.*, mandible; *pcl.*, postclypeus; *pmt.*, postmentum; *pt.*, posterior; *rt.*, right.

apilose strip. Postclypeus subrectangular, wider than anteclypeus, and not distinctly separable from frons; anterior margin straight. *Labrum:* Distal part subtriangular with a bluntly pointed tip; sides in posterior two-thirds straight and subparallel; with several long setae on tip and on body. *Mandibles:* Thick and stout; broadest basally and narrowing in front into a sharp inwardly bent tip. Left mandible with a large, prominent tooth near the middle of inner margin. Right mandible with a minute corresponding tooth. *Postmentum:* Subrectangular; broadest at beginning of anterior one-fourth, whence the sides narrowing in front; posteriorly, the sides almost straight; anterior margin straight; posterior margin concave, with a weak median bulge.

Thorax: Pronotum: Saddle-shaped; much broader than long; narrower than head; with a moderate number of short hairs on margins and body; anterior margin round with a deep median notch; antero-lateral corners rounded; posteriorly, the sides converging into broadly rounded postero-lateral corners; posterior border convex with a prominent median notch. *Mesonotum:* Much narrower than pronotum or metanotum; posterior margin prominently incurved. *Metanotum:* Slightly narrower than pronotum; posterior margin almost straight. *Legs:* Long and thin; hairy; tibial spurs 3 in forelegs and 2 each in middle- and hindlegs. Tarsi 4-jointed.

TABLE II. BODY-MEASUREMENTS (IN MM.) AND INDICES OF *ODONTOTERMES METURENSIS* Roonwal and Chhotani

Caste: Soldier

	Body-parts	Range (4–6 specimens)	Holotype
	I GENERAL		
1.	Total body-length *ca.*	6·30 – 7·35	7·00
	II HEAD		
2.	Length of head to lateral base of mandibles	2·00 – 2·10	2·08
3.	Maximum width of head	1·45 – 1·55	1·53
4.	Maximum height of head	1·00 – 1·05	1·00
5.	Head-index I (Width/Length)	0·71 – 0·77	0·74
6.	Head-index II (Height/Width)	0·65 – 0·69	0·65
7.	Head-index III (Height/Length)	0·48 – 0·52	0·48
8.	Median length of labrum	0·33 – 0·43	0·38
9.	Maximum width of labrum	0·35 – 0·38	0·38
10.	Minimum length of mandibles (distal tip to upper base of outer condyle)		
	(*a*) Left mandible	1·20 – 1·23	1·20
	(*b*) Right mandible	1·20 – 1·23	1·20

(The number measured is given in brackets)

TABLE II. (*Contd.*)

	Body-parts	Range (4–6 specimens)	Holotype
11.	Basal width of left mandible	0·45 – 0·48	0·45
12.	Left mandibular tooth distance (Distal tip of mandible to base of tooth)	0·55 – 0·58	0·58
13.	Head-mandibular length index (Left mandible length/Head-length)	0·58 – 0·59	0·58
14.	Left mandibular tooth index (Tooth distance/Mandible length)	0·45 – 0·48	0·47
15.	Left mandible index (Basal width/Length)	0·38 – 0·40	0·38
16.	Minimum (median) length of postmentum	1·33 – 1·43	1·43
17.	Maximum width of postmentum	0·55 – 0·60	0·60
18.	Minimum width of postmentum (waist)	0·50 – 0·55	0·55
19.	Width of postmentum at anterior margin	0·40 – 0·43	0·43
	III. THORAX		
20.	Maximum length of pronotum	0·63 – 0·70	0·70
21.	Maximum width of pronotum	1·05 – 1·20	1·18
22.	Pronotum-head index (Pronotum-width/Head-width)	0·72 – 0·77	0·77

(The number measured is given in brackets)

Abdomen: Elongate, hairy. Cerci 2-jointed; 0·13-0·15 mm. long. Styli single-jointed, 0·075-0·10 mm. long.

Measurements: See Table II.

WORKER MAJOR (Plate IV)

General: Head-capsule yellow; antennae and labrum paler; mandibles yellowish, tooth margins dark brown; pronotum, legs and body pale yellow. Head-capsule moderately hairy; pronotum and body thickly hairy.

Head: Subcircular; broader than long, broadest a little posterior to base of mandibles; frons slightly sloping in front; sides weakly converging posteriorly into a round posterior border. *Fontanelle:* Indistinct. *Eyes and ocelli:* Absent. *Antennae:* With 17 segments; pilosity as in soldier; segments 1 and 2 as in soldier; segment 3 shortest; 4 longer than either 3 or 5; 5 subequal to 3; 6-16 (penultimate) gradually becoming club-shaped; 17 (terminal) ovate. *Clypeus:* Divided into an ante- and a postclypeus. Anteclypeus an apilose, flat, white strip with a semilunar, chitinoid yellow band in middle; anterior margin projected infront in middle. Postclypeus yellowish, pilose, swollen and divided incompletely into right and left halves by a median line. *Labrum:*

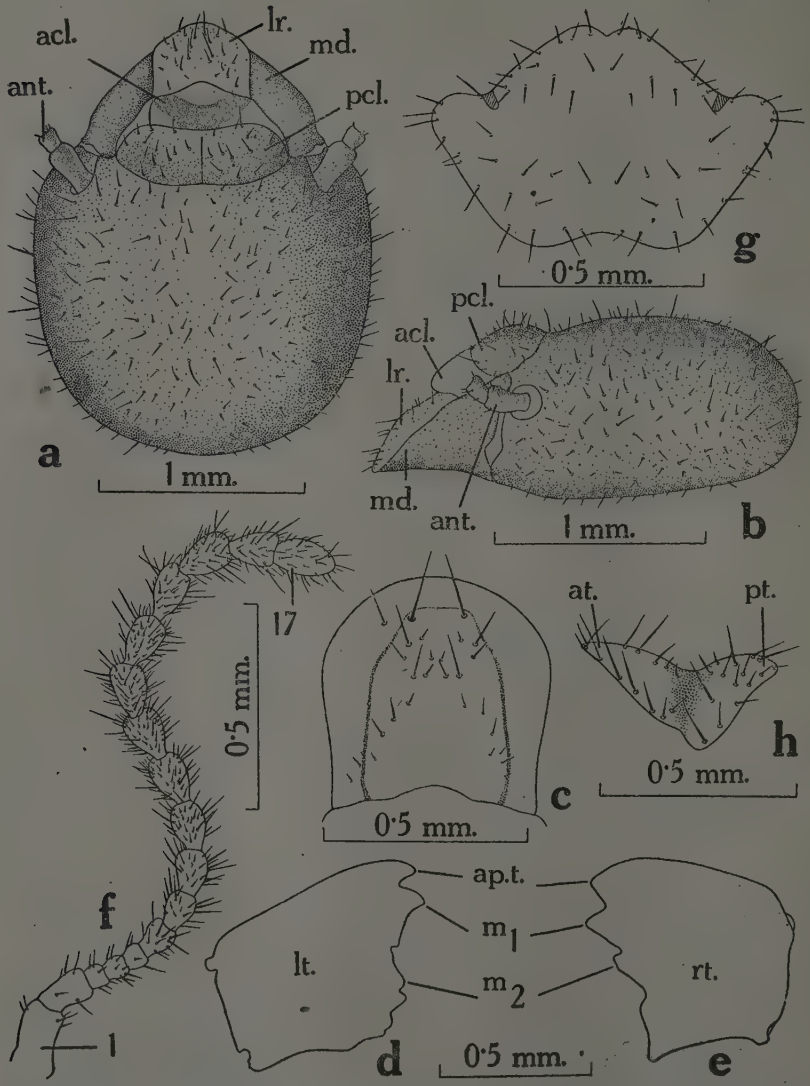

PLATE IV. ODONTOTERMES METURENSIS Roonwal and Chhotani—Worker (major) caste.

All figures are from the paramorphotype workers major from Hoganikal Falls, Metur Dam (Madras), coll. *Vazirani*, 1952.

(a) Head, in dorsal view; (b) Head, inside view (left); (c) Labrum, in dorsal view (Slide No. 2.); (d) Left mandible, in dorsal view (Slide No. 2); (e) Ditto, right mandible; (f) Right antenna, in dorsal view. First and last (17th) segments numbered (Slide No. 2.); (g) Pronotum, in dorsal view (*in situ*); (h) Pronotum, in side view (*in situ*).

acl., anteclypeus; *ant.*, antenna; *ap.t.*, apical tooth of mandible; *at.*, anterior; *lr.*, labrum; *lt.*, left; m_1—m_2, first and second marginal teeth respectively of mandibles; *md.*, mandible; *pcl.*, postclypeus; *pt.*, posterior; *rt.*, right.

Squarish, broadest at anterior one-third; anterior margin prominently convex; posteriorly sides narrowing weakly; with a few long and short hairs near anterior margin and on body. *Mandibles:* Squarish. Teeth in both mandibles large, but rather blunt, and not sharp and pointed as in the related species. Left mandible with an apical and two marginal teeth; apical finger-like; 1st marginal longer than apical, and separated from the 2nd by a wide margin with a prominent notch in the middle; 2nd much smaller than 1st. Right mandible also with an apical and two marginals; apical broad and blunt; 1st marginal subtriangular and longer than apical; 2nd marginal smaller than 1st.

Thorax: Pronotum: As in soldier, except that anterior lobe more upturned and projected in front. *Mesonotum:* Narrower than pronotum; posterior margin slightly incurved. *Metanotum:* Broader than pronotum; posterior margin straight. *Legs:* As in soldier.

Abdomen: Elongate. Cerci 2-jointed, 0·10-0·13 mm. long. Styli single-jointed 0·08-0·10 mm. long.

WORKER MINOR

Similar to worker major, but differs as follows: Body smaller and paler; head in profile swollen in middle; antennae with 16 segments (*vs.* 17) and with the 4th segment shortest (3rd shortest in worker major).

Measurements (in mm.) of major and minor workers of *Odontotermes meturensis* Roonwal and Chhotani are given below:

	Workers major (2)	*Workers minor* (2)
1. Total body-length *ca.*	4·88 – 5·40	3·45 – 4·00
2. Length of head to lateral base of mandibles	1·33 – 1·38	0·80 – 0·83
3. Maximum width of head	1·48 – 1·53	0·95 – 0·98
4. Height of head	0·63 – 0·68	0·40 – 0·43
5. Maximum length of pronotum	0·40 – 0·45	0·33 – 0·35
6. Maximum width of pronotum	0·80	0·63

(The number measured is given within brackets)

TYPE-SPECIMENS: *Holotype:* A holotype soldier (with left foreleg broken), Z.S.I. Reg. No. 2376/H8, in spirit, collection data given as in Materials (i) above. Deposited in Z.S.I.

Morphotypes: Two morphotype workers (one major and one minor) from holotype lot, Z.S.I. Reg. No. 2377/H8, in spirit. Deposited in Z.S.I.

Paratype and paramorphotypes: (1) One paratype soldier and 5 paramorphotype workers (4 major and 1 minor) from the holotype lot, in spirit, Z.S.I. Reg. No. 2378/H8; two vials, Z.S.I. Reg. Nos. 2379/H8 and 2380/H8, *vide* Material (ii) and (iii) above; and a paramorphotype worker slide, Z.S.I. Reg. No. 2381/H8. All these deposited in

the Zoological Survey of India, Calcutta. (2) Two paratype soldiers and 5 paramorphotype workers (4 major and 1 minor) from the holotype lot, deposited with Professor A. E. Emerson, Department of Zoology, University of Chicago, Chicago (U.S.A.).

TYPE-LOCALITY: *India:* Hoganikal Falls, Mettur Dam (11° 52′ N. lat.; 77° 50′ E. long), Madras State.

TYPE-HOST: A log of wood of unknown species.

DISTRIBUTION: *India:* Southern India, as follows: Bangalore (Mysore State); and Mettur Dam (Madras State).

COMPARISON: *Odontotermes meturensis* Roonwal and Chhotani is very close to *O. anamallensis* Holmg. and Holmg. and fairly closed to *O. oblongatus* Holmg., but differs from them as follows:

(1) *From O. anamallensis*

Soldier: (a) Head-capsule narrower and more slender (maximum head-width 1·45-1·50 *vs.* about 1·70-1·79 mm.). (b) Mandibles slightly longer (1·20-1·23 vs. 1·18 mm.; index mandible-length/head-length 0·58-0·59 *vs.* 0·55). (c) Mandibular tooth on left mandible somewhat more posteriorly placed (index tooth-distance/mandible-length 0·45-0·48 vs. 0·41). (d) Postmentum narrower (index maximum width/length 0·40-0·44 vs. 0·49). (e) Pronotum narrower (maximum width 1·05-1·18 *vs.* 1·23-1·29 mm.). (f) Antennae 16-segmented, with segment 4 shorter than 3 (in *anamallensis* 17-segmented, with segment 4 longer than 3).

No "smaller soldier" known in *O. meturensis*. From the "smaller soldier" of *O. anamallensis* (vide Holmgren and Holmgren, 1917, p. 158) the soldiers of *O. meturensis* are easily distinguished by their longer and narrower head (head-length 2·0-2·10 *vs.* 1·79 mm.; the width does not differ).

Worker: (a) Antennae 17-segmented (19-segmented in *O. anamallensis*). (b) Head narrower (head-width 1·48-1·53 *vs.* 1·70-1·79 mm.). (c) Mandibles with blunt and shallowly indented teeth (in *anamallensis* teeth sharp and deeply indented).

(2) *From O. oblongatus*

Soldier: (i) Larger as a whole (head-length 2·00-2·10 *vs.* 1·90 mm.; head-width 1·45-1·50 *vs.* 1·30-1·33 mm.; pronotum-width 1·05-1·18 *vs.* 0·95 mm.). (ii) Mandibles thinner and longer both absolutely and relative to head-length (length 1·20-1·23 *vs.* 0·95 mm.; head-mandibular length index 0·58-0·59 *vs.* 0·50); basal width of left mandible subequal in two species; but index basal width/mandible-length 0·38-0·40 *vs.* 0·47 (iii) Left mandibular tooth lying in the middle third of mandible-length in both species, but placed more posteriorly (almost near the middle of length) in *O. meturensis* than in *O. oblongatus*; index tooth distance/mandible-length 0·45-0·48 *vs.* 0·40.

Worker: Somewhat larger than that of *O. oblongatus* (head-width 1·48-1·53 *vs.* 1·38 mm.); pronotum-width 0·80 *vs.* 0·70-0·73 mm.).

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FLORAL MORPHOLOGY AND BLOSSOM BIOLOGY STUDIES ON SOME ANNONACEAE

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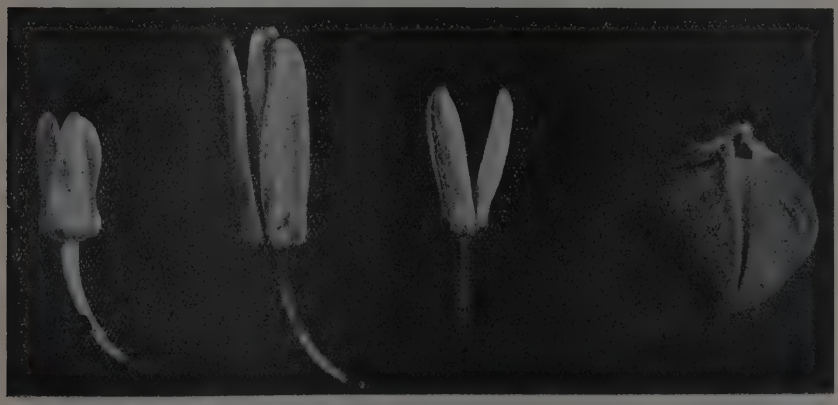
Tropical America is considered to be the home of Annonaceous species; and a few of them grow wild in many parts of India; the popular Asoka tree, *Polyalthia longifolia*, and *Artabotrys odoratissimus*, the Champaka, are common garden plants. Most of the species grow wild in South Telingana region of the Deccan and Central India. Annonaceous plants prefer dry warm climate and cannot withstand frost or low temperature.

Three Annonaceous species, viz., *Annona squamosa* Lin. (Sitaphal), *A. reticulata* Linn., (Bullock's heart) and *A. muricata* L. (Soursop) are common in the Decan Plateau. Of these *A. squamosa*, predominantly inhabits hillocks, gravelly soils, wastelands, etc. It occurs largely in red shallow gravelly soils of Telingana in the forests of Mahabubnagar, Medak, and Nalgonda districts covering roughly an area of 1,000 square miles.

All the three species of *Annona* seem to thrive well in rocky areas and in places where gravelly subsoils occur, as is evident from their large scale occurrence in Mexico and other parts of South America. *A. squamosa*, is named Aztec, which means that it grows on stony ground. Sturrock reported that *A. squamosa* is at home in pot coral rocks of the Florida keys.



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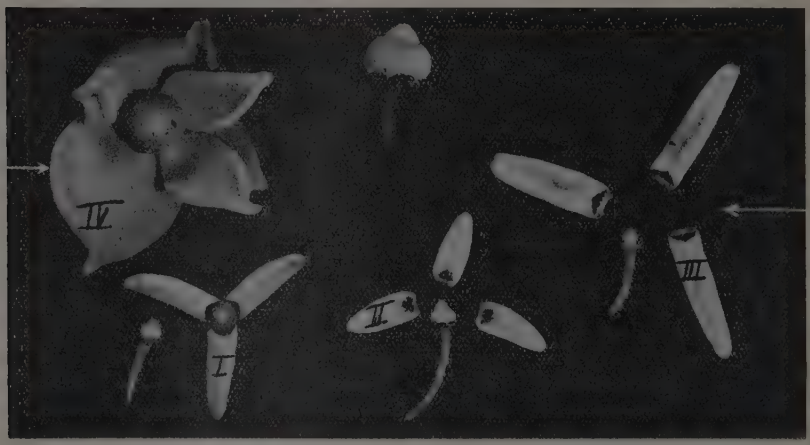
FLOWERS OF: 1. *Annona raticulata* 2. *A. cherimola* 3. *A. squamosa* 4. *A. muricata*

MATERIAL AND METHODS

With a view to improve the Annonaceous fruits, the Indian Council of Agricultural Research, sponsored a scheme sometime back for investigation into these crops.

Five species of *Annona* were collected and planted in about six acres of land at the Fruit Research Station, Sangareddy in 1944. Of these *A. squamosa*, *A. reticulata* and *A. muricata* were collected locally; and *cherimola* Mill and *glabra* Lin. were obtained from Lalbagh Botanical Gardens, Bangalore. Besides, a number of varieties of *squamosa* were obtained from New Guinea, Philippines and Barbados.



FLORAL PARTS OF: I. *A. squamosa* II. *A. reticulata* III. *A. cherimola* IV. *A. muricata*

OBSERVATIONS

Floral Morphology

The five species of *Annona* considered here generally come to blossom after four or five years. Their vegetative, flowering and dormancy periods are summarized in Table 1. Though slow growing in habit they are highly resistant to drought. Usually they go to dormancy in the months of November-December and shed their leaves completely. This behaviour is uniform for all the species of *Annona* irrespective of their vegetative and blossom flushes.

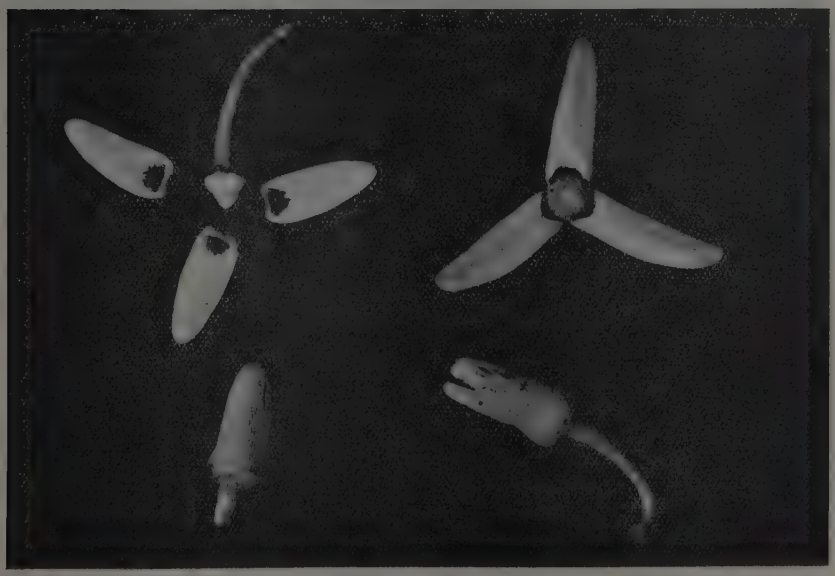
Blossom Biology

Two distinct vegetative flushes occur in all the species, i.e. (a) one in summer during February to April, and another from June starting with the onset of southwest monsoons. Profuse blossoming occurs in summer along with new vegetative flush as the plants emerge from their dormancy; and (b) the second commences in the rainy season and extends even up to winter in some species.

Irrespective of the time of blossoms, the *Annonas* are found to give crop only once a year. Summer blossom in *A. squamosa* produces stray fruits which mature in August. The flowers emit distinct fragrance of varying intensity after their petals open. In each flower stigma starts respectively just after the petals split open but become non-receptive after the another dehisce. In *A cherimola*, *A. squamosa* and *A.*

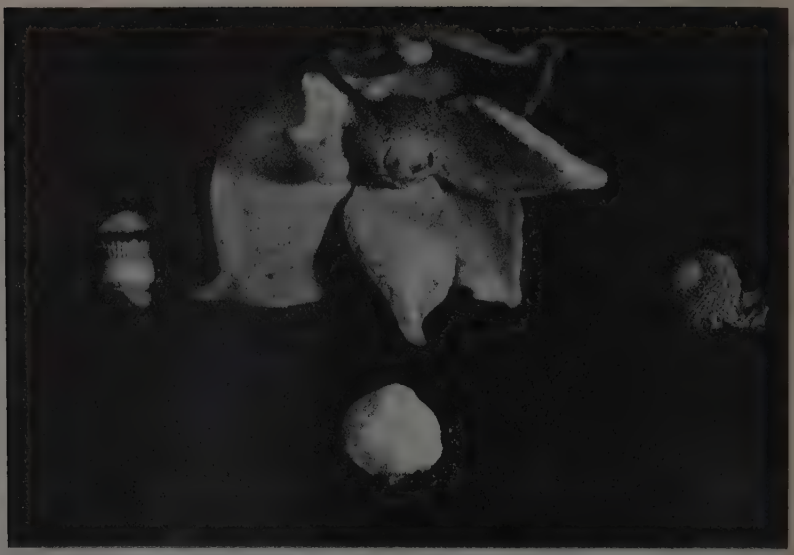
TABLE 1. VEGETATIVE BLOSSOM FLUSH AND DORMANCY PERIODS OF ANNONA

Name of Species	Flush		Dormancy period	Fruiting time
	Vegetative	Blossom		
squamosa	June	July	End of November	October
	September	September		Mid December
	February	March		
	April	April		
cherimola	June	Mid July	December	November
	October			January
	February	October		
	April	March		
		Mid May		
glabra	January	July	,,	October; end of December
	September	September		
	February	March		
	April	April		
muricata	June	August	,,	April; June
	Mid November	Mid December		
	End of January to April	End of January		
		Mid March		
reticulata	June	August	,,	March; mid-of May
	November	November		
	March April	Mid May		



FLORAL PARTS OF *ANNONA RELICULATA*

reticulata anthers dehisce just after petals unfold completely. The petals drop off in 24-48 hours excepting in *squamosa*, where they stay for a few days.



FLORAL PARTS OF *ANNONA MURICATA*

Results of anthesis studies in *Annona* are given in Table III.

Annonas were observed to be dichogamous in habit. Soon after the anther dehisced, the stigma turned brown and became non-receptive. Irrespective of temperature and humidity, anther dehiscence was found time-bound, both in summer and in rainy or winter seasons. The maximum number of flowers were found to open in *cherimola* between 4 to 8 a.m. and again between 4 to 8 p.m. In case of *squamosa* and *reticulata* they opened between 12 midnight to 8 a.m. In *muricata*, the flowers mostly opened between 12 noon to 8 p.m. and again between 4 to 8 a.m. The period of anther dehiscence was found as follows:

A. squamosa	4 a.m. to 8 a.m.
A. cherimola	4 p.m. to 8 p.m.
A. reticulata	4 p.m. to 8 p.m.
A. glabra	12 midnight to 4 a.m.
A. muricata	4 a.m. to 8 a.m.

During blossoming periods of the above species anther dehiscence, within a certain range of time, was found to be a specific character in each species.

The dichogamous habit in the species studied was responsible for a very low degree of pollination and fertilization. The stigmas remained receptive for two to three hours only and during this short period anther dehiscence was negligible. Hybridisation between different species had great limitations due to this feature.

TABLE II. FLORAL CHARACTERS OF FIVE SPECIES OF *ANNONA*

Particulars	*muricata*	*reticulata*	*glabra*	*cherimola*	*squamosa*
Inflorescence	Axillary and occurs in singles	Extra axillary emerge from new branches. Usually solitary	Flowers solitary occur in axils on old wood. Size varies much and ranges from 3 to 3·5 cm. in diameter	Usually extra axillary on both old and new wood, in singles and clusters of 2 or 3.	Extra axillary in clusters of 2, 3 and 4
Bracteole	Bracteole 0·3 cm. wide and 1·2 cm. long, perpendicular to the stalk	Distinct bracteole 0·2 cm. long and 0·26 cm. wide present. Membraneous greenish yellow in colour	Bract and bracteole are 0·8 c.m. apart, bracteole membranous	Scale like bracteole present	Pale brown minute membranous, bracteole present
Peduncle	Peduncle stout and thick 1·8 cm. long and 0·4 cm. wide and inserted deeply pyramidal at apex	Peduncle linear 2·1 cm. long and 0·25 cm. wide at point of insertion	Peduncle fleshy, glabrous, yellowish green with white spots. Stalk 1·4 cm. long and 0·4 cms. wide at point of insertion	Flowers very fragrant and tomentose. Peduncle linear, tomentose, 1·5 cm. long and 0·3 cm. wide at point of insertion	Slender, Pilose, 1·3 cm. long 0·28 cm. wide, pubescent, pyramidal at point of insertion.
Calyx	Valvate, cordate in shape, glabrous leathery green with a midrib 0·6 cm. long at base and 0·3 cm. wide, pointed upwards. At the base there is a semi-circular white spot	Tomentose and yellowish green in colour. Sepals 3 valvate 0·2 cm. long and 0·1 cm. thick.	Gamosepalous, whorled, semilunar and yellowish cream in colour. 0·7-0·9 cm. long, 0·5-0·6 cm. wide and 0·1 cm. thick. Sepals are marked with antique red spot at base	Sepals 3 cream yellow pyramidal in shape 0·3 cm. long and on 0·4 cm. at base.	Sepals valvate triquetrous, pubescent 0·2 cms. long, 0·2 wide, light yellow in colour, and 0·09 cm. thick.
Corolla	Exterior petals 3 valvate, polypetalous cordate in shape and leaf like in structure with a midrib in the centre. Petals 3·7-3·8 cm., long, 3·0-3·2 cm. wide	Exterior petals tomentose fleshy and oblong. 2·4 to 2·6 cm. long, 0·7-0·8 cm. wide and 0·3 cm. thick. Apex of petals is rounded and inner side of petals	Exterior petals valvate, fleshy, glabrous, thick and rounded at apex. A centre nerve passes from bottom to apex. 3·5-3·6 cm. long and 2·9-3·1 cm. broad and	Exterior petals cream yellow, oblong linear and tapering, apex rounded. Keel shaped inside tomentose. The dimensions of three petals are:	

TABLE II. FLORAL CHARACTERS OF FIVE SPECIES OF *ANNONA*.—(*Contd.*)

Particulars	*muricata*	*reticulata*	*glabra*	*cherimola*			*squamosa*
	and 0·2 cm. thick. Inner petals 3 keeled, narrowed at base pale yellow with indistinct mid-rib, imbricate or overlaping apex round. 2·6-3·1 cm. long, 2·0 cm. wide and 0·2 diameter	distinct blotch a dark purple in colour in present inner petals are ovate, acute scale like 1·1 cm. long and 0·09 cms. wide. These are concave with a line in the centre	0·3 cm. thick at base and 0·4-0·5 cm. thick at apex. Inner petals thick fleshy, boat shaped and concave. From ⅓ of the base they are vinousmauve uptoapex. *A red spot occurs near the base* glabrous, thick and leathery, 2·5 cms. long 1·4-1·7 cm. wide and 0·2-0·3 cm. thick	*Length* cm. 4·1 3·9 3·8	*Breadth* cm. 0·98 0·90 0·89	*Width* cm. 0·50 0·40 0·49	
Androceium	Androceium is a distinct enlarged disc 1·68 cm. wide and 0·95 cm. high with innumerable stamens. Stamens 0·3 cms. 0·4 long, innumerables; hypogynous	Disc shaped 0·6 cm. diameter 0·3 cm; high dull while with innumerable stamens. Stamens sessile indistinct, cinnamon brown	A distinct wavy line separates the androceium from gynoecium. Stamens innumerable, hypogynous, 0·3-0·4 cm. long. Connective protrudes the anthers and dilated at tip. Pollen spore is spherical transparent white and double that of *Annona squamosa*	Disc shaped with indefinite stamens 0·2 cm. long. Disc 0·3 cm. wide and 0·85 cm. spread; white in colour before dehiscence of anthers and later becomes rusty brown			Disc shaped 0·3 cm. wide around the receptacle, 0·6 cm. diameter and 0·08 cm. in height. Stamens 0·13 cms. long, innumerable with broad terminal connective of orange red colour
Gynoecium	The gynoecium is superior 0·3 cm. high and conical over the androecium disc. It is tapering, with pyramidal aggregate with numerous carpels fused. These carpels protrude distinctly with shiny white stigmas which are clothed with silky hairs	Aggregate monocarpellary ovaries triangular and pyramidal in shape. Gynoecium 0·3 cm. long, 0·2 cm. wide, carpels distinct, covered with pale brown silky hairs Stigma short conical with minute hair like structures	Many single carpelled aggregate ovaries superior with glabrous, rounded stigmas	Aggregate monocarpadlary ovary with feathery linear stigmas. Ovary superior with basal placentation and the syncarpous gynoecium is 0·2 cm. wide and conical			Aggregate carpels distinctly seen. The gynoecium is conical dull white in colour and 0·34 cm. high over the staminal column. Stigmas linear, minute feathery.

TABLE III. STATEMENT SHOWING ANTHESIS STUDIES IN ANNONACEOUS SPECIES

Name	Minimum period taken for flower opening	Maximum period taken	No. of flowers studied	12 midnight to 4.00 a. m.				4.00 a. m. to 8.00 a. m.				8.00 a. m. to 12 noon	
				No. of flowers opened	% of flowers opened	No. of flowers completed opening	% of flowers completed opening	No. of flowers opened	% of flowers opened	No. of flowers completed opening	% of flowers completed opening	No. of flowers opened	% of flowers opened
	Hrs. Mts.	Hrs. Mts.											
cherimola	9–30	36–15	53	3	5·66	..	..	14	26·42	..	..	4	7·55
reticulata form *squamosa*	28–50	55–26	51	..	..	..	..	13	25·49	..	..	32	62·75
reticulata finger printed form	26–40	78–7	73	4	5·48	..	..	13	17·81	..	..	34	46·57
squamosa	23–20	69–55	59	10	16·95	..	..	19	32·20	59	100	19	32·20
glabra	21–20	26–00	9	6	66·67	9	100	3	33·33	..	..	..	..
muricata	13–25	70–00	9	..	..	3	33·33	4	44·44	6	66·67	...	..

Name	12 noon to 4.00 p. m.				4.00 p.m. to 8 p.m.				8 p.m. to 12 midnight			
	No. of flowers opened	% of flowers opened	No. of flowers completed opening	% of flowers completed opening	No. of flowers opened	% of flowers opened	No. of flowers completed opening	% of flowers completed opening	No. of flowers opened	% of flowers opened	No. of flowers completed opening	% of flowers completed opening
cherimola	7	13·21	..	..	19	35·35	53	100	6	11·31	..	..
reticulata form *squamosa*	3	3·88	2	3·92	2	3·92	49	96·08	1	1·96	..	..
reticulata finger printed form	3	4·11	3	4·11	11	15·07	69	94·52	3	10·96	1	1·87
squamosa	5	10·17	..	..	3	5·09	..	..	2	3·39	..	..
glabra	..	..	..	..	..	..	..	..	..	..	..	..
muricata	3	33·33	..	..	2	22·22	..	..	..	..	..	..

SUMMARY

Floral characters and blossom biology were studied in five species of *Annona*. They were found to blossom twice a year; the summer blossoms failing to set fruit and the other blossom alone resulting in fruiting.

Irrespective of temperature and humidity, anther dehiscences was found time bound.

All species of *Annonas* were found dichogamous in habit resulting in cross pollination in the species.

ACKNOWLEDGEMENTS

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A NOTE ON THE AXILLARY BUD DEVELOPMENT IN *MUSA SUPERBA* ROXB.

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The non-stooling monocarpic species of *Musa* with bottle-shaped pseudostem and fruits with few large seeds have been brought up by Cheesman (1947) under *physocaulis*, a sub-group having a haploid number of nine chromosomes. He has revived Horainow's genus *Ensete*, and according to this new conception, *Musa superba*, a wild species of *Musa* occurring in the western and eastern hill ranges of South India and Ceylon and generally exhibiting the characteristics of the above group, has been renamed as *Ensete superbum* Horan. Multiplication in this species is entirely by sexual means. As far as the authors are aware vegetative regeneration in this species is unknown. The present note gives an instance of axillary bud development in a plant of *Musa superba* Roxb. noted at the Central Banana Research Station, Aduthurai.

Due to severe summer drought, the aerial portion of the plant described here withered and dried leaves and sheaths were pruned and removed. A few months later, it received a fair supply of water from a neighbouring water channel which was supplemented by occasional showers. As a result of this, the plant gave forth vigorous side-shoots, eleven in number. The asexual off-springs were quite normal and healthy.

The stool was excavated about two months after the emergence of the first shoot and by this time, each individual shoot had developed its own root system; but the old roots of parent plant had suffered decay. On examination, each vegetative shoot was found to possess a small corm attached to the mother plant by a narrow link, making the separation of these plants easy.

The abnormality described above indicates that *Ensete superbum* Horan hitherto considered as non-stooling, is potentially capable of reproducing itself by vegetative means.

ACKNOWLEDGEMENTS

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THE TRACE ELEMENTS IN WHEAT STARCHES

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Considerable information concerning the structure and composition of starch is now available but very little is known as to the trace elements carried down with starch during its preparation. Very little attempt seems to have been made hitherto to detect and determine these trace elements and to explore any possible relationship between them and the baking properties of starches. It is conceivable that the baking properties of starches may be considerably modified by the presence of these elements influencing the course of the enzymatic reactions occurring in media containing starch in the form of a paste or batter. In view of this consideration, a study has been made to determine the trace elements present in wheat starches obtained from plants grown at different soil fertility levels.

The presence of phosphorus, silicon, calcium, magnesium, potassium and iron in starches has been established by Mangel (1934), Kniaginichev (1938), Janicki (1932), Samec (1927), Nottin (1934), Strohecker (1935) and El-Gindy (1957). The following are the values given by previous investigators for the mineral elements present in dry starch:

P	..	0·055-0·128 per cent
SiO_2	..	0·019 per cent
CaO	..	0·042 ,, ,,
MgO	..	0·026 ,, ,,
K_2O	..	0·027 ,, ,,
Fe_2O_3	..	trace

Nottin (1934) estimated that 45·3 per cent of phosphorus present in wheat could be recovered from the isolated starch.

MATERIAL AND METHODS

White wheat Cornell 595, soft wheat Seneca and hard wheat Pawnee were grown at eight different fertility levels with combinations of 19 kg. nitrogen, 43·5 kg. of P_2O_5 and 43·5 kg. of potassium per acre. Wheat kernels were milled and fractionated for analysis into gluten, starch and water solubles according to the modified procedure of Yamasaki (1953). Flour (400 gm.) suspended in distilled water (1,200 ml.) was centrifuged at 1,800 r.p.m. for 25 minutes. After 30 minutes the dough was kneaded to separate the gluten, and the starch removed from the liquid by centrifugation at 1,800 r.p.m. for 15 minutes. The gluten and the supernatant liquid containing the water solubles were immediately frozen. The three fractions were finally dried by evaporation *in vacuo*. For analysis, an amount of the substance containing 20 mg. of ash, mixed with 180 mg. of lithium fluoride was ashed at 525°C. The resulting

residue was ground in agate mortar and arced on purified electrodes. Spectrograms were recorded on plates and the densities of the lines representing the elements were noted. The data were expressed quantitatively by the use of standard curves obtained from arcing synthetic ashes. Ratios of line densities to those of the internal standard lithium fluoride were used for the analysis of variance of boron and iron. In case of copper, it was ascertained as mg. of copper per 100 gm. of ash.

The whole procedure of growing wheat plants and analysing both the wheat kernels and the starches was repeated in the following season to make sure that the nitrogen-phosphorus-potassium levels as well as of the trace elements of the original untreated soil did not interfere with the interpretation of the results obtained in this comparative study.

RESULTS AND DISCUSSION

The data obtained for the major elements is recorded in Table I, and that for the trace elements is recorded in Tables II and III.

Table I shows that the major elements recovered from the starch fractions fall within the following limits: Mg, 1·38-17·35 per cent; Mn, 0·17-8·01 per cent; Si, 1·26-16·94 per cent; Al, 4·50-59·46 per cent; Ca, 5·58-53·62 per cent; K, 1·07-9·55 per cent. Average for the two successive crops put together were: Mg, 5·45 per cent; Mn, 1·77 per cent; Si, 4·67 per cent; Al, 15·66 per cent; K, 4·28 per cent. As there is no significant pattern noticeable in the variation of the concentration of these mineral elements, it is difficult to correlate the influence of the variety of the wheat or soil treatment with such changes.

The amount of trace elements calculated as parts per million (Tables II and III) fall within the following limits: B, 0·37-3·50; Fe, 2·23-26·68; Sn, 1·61-4·32; Cu, 0·21-0.74; Ag, 0·52-0·98; Zn, 1·86-4·65. Averages for the two crops were: B, 0·80; Fe, 10·05; Sn, 2·51; Cu, 0·43; Ag. 0·68; Zn, 2·77.

The percentages of these elements appearing in the starch fractions compared to the whole wheat are as follows: B, 3·30-50·38 per cent; (average, 8·99 per cent); Fe, 1·61-22·18 per cent (average, 5·68 per cent); Sn, 9·35-26·72 per cent (average, 14·47 per cent); Cu, 1·04-3·76 per cent (average 2·17 per cent); Ag, 5·65-13·15 per cent (average 8·46 per cent); Zn, 2·05-8·66 per cent (average, 4·75 per cent).

Statistical analysis of variance revealed that the differences in boron, iron and copper content of the three varieties of wheat were significant. F values were found to be 4·98, 3·75 and 37·80 respectively.

The starch samples obtained from the three varieties of wheat showed differences in their baking properties. A study as to the effect of various concentrations of the trace elements present in the dough has been undertaken and is still in progress.

SUMMARY

The amount of magnesium, manganese, silicon, aluminium, calcium, potassium, boron, iron, tin, copper, silver and zinc have been determined in starch samples obtained from three varieties of wheat grown at different soil fertility levels.

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BIOLOGY OF *ALCIDODES AFFABER* AURIVILLIUS*

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Alcidodes affaber, Aurivillius is a stem weevil, which attacks some of the Malvaceous plants like *Bhendi* (*Hibiscus esculenies*), Cotton (*Gossypium* sp.), Gogu (*Hibiscus cannabinus*) etc. causing appreciable damage in South India. The weevil belongs to the subfamily *Alcidodinae* of the family *Curculionidae*. It was first described by Aurivillius in 1891 and since then as far as the author is aware, there appears to be no reference on this weevil until 1919 when Flectcher mentioned about its occurrence, distribution and host plants. Later Ayyar T.V.R. [1922, 1940] gave a brief account of this species. Both Flectcher and Ayyar T.V.R. record it in Coimbatore on cotton, bhendi and gogu and it was also noted by the latter on paddy at Shoranur (Malabar). Further reports on this weevil are from Bengal on *Ficus bengalensis* [Beeson 1919], Saidapet on tree cottons [Rao 1919], Ceylon on kapak *Eriodendron anfractuosum* [Huston 1930], Punjab on cotton [Hussain 1925] and Dehradun on *Hibiscus mutabilis*, *Kydia calcyina*, *Bombax malabaricum* and *Althea rosea* [Gardner1934]. Apart from these references, which give only a brief account of the insect, there is no information on the life history of the weevil, Hence, a detailed study on the biology of the insect was undertaken at Coimbatore during 1953-54 and the results are presented in this paper.

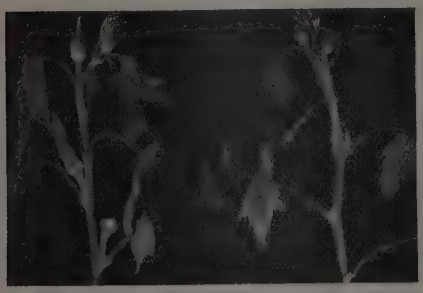

FIG. 1. ATTACKED BHENDI PLANTS SHOWING NODULAR SWELLINGS.

FIG. 2. LEAF PETIOLE SHOWING THE DAMAGE.

Nature of damage: The adults feed on leaf buds, petioles and tender terminal portions. The damage done by adults is quite insignificant. The grubs do serious damage to the plant by boring the stems and petioles and feeding on them. In the initial stages they feed on the tissue immediately around the point of entry resulting in a gall-like swelling around the seat of injury. Later they gradually bore directly

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downwards if the eggs have been laid at the terminal end, and when the eggs are laid in the petiole they bore the petiole and reach the nodal region from where they travel downwards. The grubs make small exit holes at the sides of stem and petioles at frequent intervals through which frass is sent out. The nature of frass varies with the plants. In cotton, it is in the form of dark brown powdery matter while in bhendi it is a frothy secretion of mucillagenous nature (Fig. 5). The infested plants are stunted and their flowers and fruits are considerably affected. A single plant may harbour as many as 12 grubs. In case of severe attack of the pest, more than 80 per cent. of the plants are infested and the loss to the bhendi crop has been estimated to be 20 to 30 per cent. Cotton, bhendi and gogu, are found to be seriously affected at Coimbatore.

FIG. 3. BHENDI STEM SHOWING THE DAMAGE.

FIG. 4. BHENDI STEM SHOWING THE FROTHY SECRETION.

Host plants: The three new host plants recorded are *Hibiscus ficulneus*, L., *Urena lobata*, L. and *Urena sinuata*.

Life-history: The life-history was worked out in the laboratory. The grubs were reared on bhendi stems, as they could be reared more easily on this plant. Knop's culture solution prepared by dissolving 2 gm. of calcium nitrate, 0·5 gm. of Monobasic potassium phosphate, and 0·5 gm. of Potassium nitrate in 350 cc. of water in which one drop of Ferric chloride (one per cent. aqueous) is added was used to keep the stems alive. Detailed observations were made on the duration of various stages of the insect, larval instars, fecundity and longevity of adults and seasonal history.

Copulation: Copulation of the weevils starts three to six days after emergence and lasts for 30-40 minutes. The weevils are rarely seen in copulation in the fields, but they freely copulate under laboratory conditions.

Pre-oviposition and egg laying: The pre-oviposition period ranged from 8-11 days. The maximum period of oviposition was 34 days and maximum number of eggs laid was 45. The daily range of egg laying was found to be one to three. Eggs are usually laid on leaf petioles and at the tender portions of the stem. The adult makes excavations, the depth of which is as long as the rostrum. Three excavations are made close to each other and the egg is laid only in the middle one. Usually only

one egg is laid in each excavation. The time taken for laying a single egg ranged from 15 to 18 mts.

Egg: The egg is creamy-white, smooth, glossy and broadly oval with anterior end slightly narrowed. Freshly laid egg measures on an average 1·17 m.m. in length and 0·63 m.m. in width. It is soft and fragile and becomes hardened in 12 hrs.

The incubation period varied from 6 to 7 days with an average of 6·2 days.

Larva: The larva passes through nine instars in the laboratory. There is not much difference in general characters among the different instars but only the size of body and head capsule vary and a slight change in coloration of head capsule also is noted in some instars. The description of the first and final instar grubs, the measurements of head and body, the duration of each instar, etc., are given in Table I.

TABLE I. DESCRIPTION OF FIRST AND FINAL INSTAR GRUBS

Instar	Body		Head		Duration in days	Mean	Remarks
	Length	Width	Length	Width			
1st. ..	1·2–1·4	0·8	0·53	0·53	5–6	5·4	Description given separately
2nd. ..	1·5–2·0	1·1	0·79	0·68	6–7	6·2	Characters similar to first instar
3rd. ..	2·0–2·5	1·1	0·89	0·81	6–7	6·4	Similar to 2nd instar
4th. ..	2·7–3·2	1·4	0·98	0·92	6–7	6·7	Colour creamy yellow. Head deep brown and finely punctate
5th. ..	3·5–4·5	1·5	1·20	1·15	6–7	6·5	Frons with irregular surface. Other characters similar to previous instar
6th. ..	4·8–6·0	1·8	1·5	1·34	6–7	6·5	Similar to 5th. instar
7th. ..	6·0–6·7	2·1	1·8	1·5	6–7	6·7	Head dark, castaneous and coarsely pitted. The testaceous colour of pronotum is distinct
8th. ..	7·0–8·0	2·5	2·1	1·8	6–7	6·8	Similar to 7th. instar
9th. ..	8·5–10·5	3·1	2·5	2·2	7–8	7·1	Characters and description given separately

First instar: Colour pale yellow. Body curved, soft and beset with soft hairs. Apodous. Head smooth, pale brown, frons with a small median dark line on the posterior end. Mandibles dark brown and bifid.

Full grown grub: A short description of the full grown grub has been given by Gardner [1943]. An attempt has been made to go into more details.

FIG. 5. STAGES OF THE WEEVIL
1. EGG. 2. EGG IN SITU. 3. FIRST INSTAR GRUB.
4. GRUBS (a), PUPAE (b) AND ADULTS (c).

Colour creamy yellow. Apodous, body stout, cylindrical, moderately curved and wrinkled. Head capsule dark castaneous, subcircular, surface irregular and deeply pitted. Epicranial suture distinct; slightly exceeding half cranial length. Frontal sutures with each arm slightly exceeding epicranial suture in length and each side of epicranium with seven setae. Frons with transverse sculpture on the surface and a dark streak on the posterior end which extends forward to about one fourth length of frons and provided with five pairs of setae. Antenna normal, the apical segment conical and longer than wide. Clypeus almost twice as wide as long with two pairs of setae on the posterior margin. Labrum transverse, posterior margin prolonged into clypeal zone; upper surface carrying three pairs of setae; the median pair longest. Epipharynx with six median setae on the anterior margin and three lateral setae on each side, a pair of slender and slightly converging rods which extends into the clypeal zone; between the rods are two pairs of setae, the anterior one much

stouter and more widely separated; in addition a pair of tripartite pores are also found between the rods. Mandibles subtriangular, bidentate and shorter than width of base. Maxilla with smooth cardo; stipes with a basal lateroventral seta and two setae in the palpiferous region; palpus two jointed, basal one as long as wide and twice as long as the apical joint; provided with a small seta and a pair of sensory pores, apical joint one and half times longer than wide and provided with one sensory pore in the

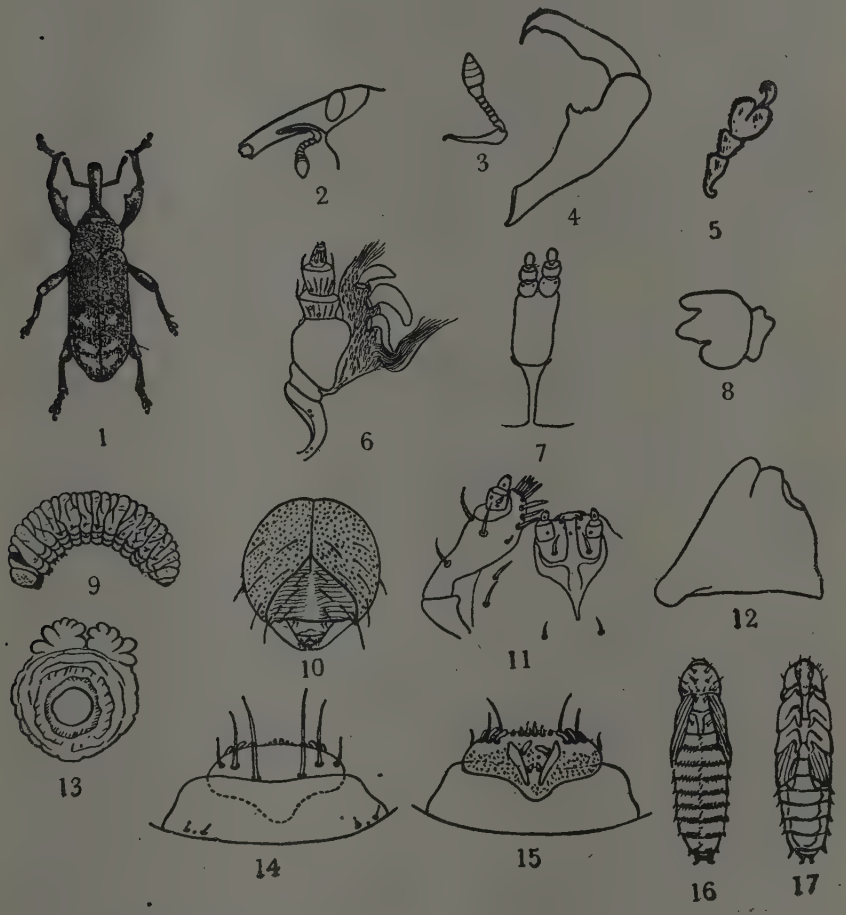

Fig. 6. Alcidodes Affaber, Aur.
1. Adult weevil. 2. Side view of head. 3. Antenna. 4. Femur and Tibia of front leg. 5. Tarsus. 6. Maxilla of adult. 7. Labium of adult. 8. Mandible of adult. 9. Grub. 10. Head capsule of grub. 11. Maxilla and Labium of grub. 12. Mandible of gurb. 13. Spiracle. 14. Labrum of grub. 15. Epipharynx of grub. 16 & 17 Pupae.

mid-region and small sensory cones at the tip; mala simple with nine to ten dagger-like setae. Labium as long as wide, posteriorly limited by a Y-shaped-chitinised band and with one pair of setae on each labial stipe; palpus two jointed each with a small sensory pore and apical joint with sensory cones at the tip; ligula with two pairs of setae anteriorly; subfascial region entire with three setae on each side. Prothroax dorsally not divided but the prescutal and scutal areas are roughly indicated by rows of setae; pronotum testaceous brown. Meso and Metathorax divisible into prescutum and scutoscutellum; the former with two small setae and the latter with four setae in a straight line. Pedal lobes prominent with four or five hairs.

Abdomen ten segmented, segments one to eight with three distinct transverse folds viz. prescutum, scutum and scutellum; a weakly-formed intersegmental fold is also visible. The prescutum with one pair of setae, scutum with one tiny seta and scutellum with four setae in a row; alar area provided with two setae. Each epipleural lobe of abdomen with a single seta and each hypopleural lobe with two setae; the last two segments simple with a number of hairs. Spiracles circular, air tubes irregular, short and do not project far beyond peritreme; posterior spiracles placed more dorsally.

The total larval period was found to vary from 55 to 62 days with an average of 59.0 days.

Larval habits: The grub is very sluggish. After hatching it starts feeding on the tissue immediately around the hole in which egg is laid and later bores downwards. It makes small exit holes on the petiole and stem to eject out the frass. Before pupation it prepares a small cavity inside the stem which is bigger than the pupa.

Prepupa: This stage is characterised by the shortening of the grub in length and slight swelling in the thoracic region. This stage lasts for about one day and the length varies from 9·5 m.m. to 9·8 m.m.

Pupa: Colour creamy yellow but turns still darker before transformation into adult. Body soft and beset with moderately long hairs. Head as long as broad and provided with five pairs of setae originating from minute tubercles consisting of one pair near the base, two pairs immediately behind the eyes and two pairs between eyes. Rostrum about one fourth total length of body and three times as long as broad with two pairs of setae in small tubercles; the anterior pair between the position where the scape is inserted and the posterior pair close to the eyes.

Prothorax about one and half times as wide as long with nine pairs of setae on raised tubercles consisting of two anterior pair three median and four posterior pairs. Mesothorax half as long as prothorax with two pairs of setae. Metathorax one and half times as long as broad and provided with three pairs of small setae. Abdomen twice longer than broad, nine segmented; segments one to eight have dorsally a transverse row of six pairs of setae on small tubercles on the posterior margin consisting of two median and four lateral pairs; in addition one pair on the pleural region. The ninth segment is provided with a pair of slender, pointed, curved, pleural process. Ventral side bare. Length 9·5 m.m. to 9·8 m.m., width 3·6 m.m. to 4·1 m.m.

Pupation takes place inside the larval burrow in the stem. The duration of the pupal stage varies from 10-12 days with an average of 10·6 days.

The total life-cycle from egg to adult varied from 72-80 days with an average of 75·4 days.

Adult: The original description of the species by Aurivillius [1891] is brief as it is based only on a few specimens. It is redescribed below after studying a larger number of specimens.

Subcylindrical; integument piceous, not densely clothed with small pale scales and more or less dusted with rust red powder. Elytra with pale markings formed of small, short, greyish white plumose scales; one small patch just beyond the middle extending from striae three, another narrow oblique band extending from the suture to the lateral margin just above the apical region and in addition a preapical band of scale extending from margin to striae three. Head broader than long, closely punctate, the forehead with a shallow median fovea and an impressed line round the upper edge of the eye. Rostrum a little shorter than front femur in both the sexes, elongate, gently curved, slightly widened at the insertion of the antennae and again at the apex. Antennae inserted in the middle of the rostrum, the scape as long as funicle which is seven jointed; joint one a little longer than two plus three; three to six bead like and transverse, seven much shorter than club which is longer than broad, conical and four jointed.

Prothorax: Broader than long, rounded at the middle, posterior end twice as broad as its anterior end, parellel sided from the base to the middle and roundly narrowed and broadly constricted at the apex, dorsal outline gently convex longitudinally; the postocular lobes feeble; dorsum with dense low rounded granules each with a short recumbent setae on its anterior edge, the interstices thinly clothed with setiform scales, the apical area shallowly punctate. Scutellum exposed and glabrous. Elytra cylindrical not broader than prothorax; striae deep with oblong foveae which are reduced behind, each containing a minute horizontal seta, but most of them more or less filled up with scalings intervals rather narrower than striae, rugosely punctate with small setiform scales. Legs dark piceous, with numerous narrow feather scales; the front femora with a stout elongated tooth beyond the middle followed by three denticulations which are largely hidden by long curved scales, posterior pairs having only one simple tooth; tibia more shallowly punctate, the front pair with a sharp laminate tooth on the inner edge about the middle and with a small tooth near the apex; the other pairs with only the apical tooth; tarsi four jointed, joint three bilobed, four ending in four small spines; the hind pair of legs smaller than the other two. Sternum with front intercoxal space narrower than the median one, the metasternum sparsely granulate.

Both the sexes are similar in general characters and difference is noted in the rostrum which is stouter, short and coarsely punctate throughout in male; and in female it is longer, moderately stout and closely punctate from base to the insertion of antennae and apical area shiny and partially punctate. Males are smaller.

Measurements: Average length of body in female is 9·8 m.m. (excluding rostrum), width 3·3 m.m. and length of rostrum 2·8 m.m.

Male: Average length of body excluding rostrum 8·5 m.m., width 3·3 m.m. and length of rostrum 2·1 m.m.

Emergence and habits: Adults emerge through the holes made by the fullgrown grubs at the sides of the stem. Newly-emerged adults are soft and delicate but get hardened in one or two days. The adults are generally less active. They are often found clinging to the terminal branches especially at the axils of the leaves. If approached they try to hide beneath the leaves and a slight disturbance makes them fall down and feign death. They are rarely seen in large numbers in the field. Though provided with fully developed hind wings, they are rarely seen in flight.

Longevity: The length of life in both the sexes was rather short in captivity. The duration with food varied from 6-43 days for females and 8-32 days for males, the average in each being 19·1 and 19·4 days respectively. Without food, the maximum life was found to be eight days in each case.

Natural enemies: Two Hymenopterous parasites have been recorded on the grubs of this weevil viz. *Aphrastobracon alcidophagus*, R (Braconidae) (Ayyar T. V. R. 1934) and *Xoridescopus* sp. (Ichneumonidae) (Krishna Ayyar 1943). No parasites were obtained during this study.

Seasonal activity: The seasonal history of the weevil was studied with reference to bhendi crop at Coimbatore The weevil is more abundant during the rainy season at Coimbatore from the months of September to December. The crop is raised at Coimbatore in two seasons. One from August to December and the other in summer from March to July. The weevil attacks only the crop raised in August and the rainy weather is found to be more condusive for breeding. Only one generation of the weevil was noted. The adults appear in the middle of September and egg laying commences by end of September. Eggs are noted from September to November, the small and medium sized grubs from the middle of October to end of November and the full-grown grubs and pupae in December. Most of the adults emerge by end of December.

SUMMARY

The biology and description of various stages of the *Alcidodes affaber*, Aur., a stem weevil of Malvaceous plants like cotton, bhendi and gogu in South India are dealt with in detail. The grubs bore the stem and cause stunted growth and reduction in yield. Eggs are laid on tender shoots and petioles in 8-11 days after emergence. The total life cycle lasts for 72 to 80 days, the duration of each stage varying from 6 to 7 days for egg, 55 to 62 days for grub and ten to 12 days for pupa. The life of adult varies from 6-43 days for females and 8-32 days for males. The maximum eggs laid by the weevil in captivity is only 45. The grub has nine instars in laboratory.

The seasonal history of the weevil at Coimbatore is described and the host plants are given.

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REVIEWS

THE WEALTH OF INDIA—(A Dictionary of Indian Raw Materials and Industrial Products). Published by Council of Scientific and Industrial Research. Vol. I-IV.

The Council of Scientific and Industrial Research have rendered a real service to the country by planning this series of publications under the title "Wealth of India" in which products of economic importance found in India are dealt with in greater detail. This series is a timely venture because the first publication on these lines was brought out as early as 1889-1899 by George Watt in his monumental work entitled "Dictionary of the Economic Products of India and the Commercial Products". Since this work was the first published, studies on the economic products of India have advanced a great deal and much new information has been collected together. In the Wealth of India series such new information now widely scattered and probably inaccessible to interested people are made conveniently available. The publicatons are encyclopaedic in character and convey to the reader the present status of knowledge of the various economic products in this country. This will surely be looked upon as a standard work of reference by scientists, research workers, administrators and people interested in trade and commerce and even the general reader will turn again and again to them for detailed information on the subjects in which he is interested. The publications include detailed self-contained essays on various topics, subjects arranged alphabetically. The essays are written by accepted authorities in the respective subjects as the information contained therein is sound, up-to-date and dependable. The publications are issued under the supervision of a strong Editorial Committee and an Advisory Board including eminent scientists, industrialists, scientists, etc. There are several sub-committees on different broadly classified subjects. So far four volumes have been issued in the series. Volume I contains the alphabetical order A to B; Volume IIC; Vol. III, D, E; Volume IV F to G. The series is neatly printed with a large number of coloured and black and white illustrations. They are securely bound and will stand constant handling. U.N.C.

MINERALS IN PASTURES (Deficiencies and Excesses in Relation to Animal Health)—F. C. Russell and D. L. Duncan (2nd Edi.). Commonwealth Bureau of Animal Nutrition Technical Communication No. 15. Price 25 s.

This is the second edition of the well-known Technical Communication prepared in 1944 by Miss Russell. Dr. Dorothy L. Duncan has introduced skillfully a lot of new material to bring this edition up-to-date. The bulletin is not only a handy reference book for all workers on animal nutrition in the field of mineral metabolism but is also of great help to stock owners and veterinarians owing to the detailed descriptions given about the clinical symptoms caused by the deficiency of essential minerals or toxicity of some of them when occurring naturally in large quantities.

It is, however, difficult to understand why the major elements have been scantily dealt with as compared to the trace elements like copper and cobalt. If this has been

done to keep down the bulk of the book, it would have been better if the title and text of the book could have been restricted to the trace elements only. In the table at the end of the book, phosphorus and iodine deficiencies have been shown to be wide spread throughout the world, though no reference to the literature about their occurrence in India has been given. Similarly, the work on fluorosis found under natural condition in India (Majumdar, Ray and Sen, *Ind. J. Vet. Sci.*, **13**: 95, 1943) and the deficiency of copper as found in many Indian forages (Sahai and Kehar, *Ind. J. Vet. Sci.*, **21**: 235, 1951) have also been over-looked. The interesting interrelationship between oxalates and calcium content of the ration and also between the absolute quantities as well as the ratio between calcium and phosphorus on the immobilization of excess dietary fluorine has also not been mentioned.

REVIEW OF PUNJAB AGRICULTURE—(Facts and Figures)—R. L. Anand.

This publication contains valuable and up-to-date information on agricultural statistics in the Punjab till the end of 1954. It is very well presented and documented. The book gives a clear idea of the changes that have taken place in agriculture since partition. The relative position of the Punjab among other States regarding developments in the agricultural sector has also been described. An overall picture of the Punjab State after the reorganisation of the States in 1956 has also been given at the end. The main topics covered are the land utilisation, areas and yields of crops, mixed crops grown, livestock and agricultural implements, sources of irrigation and areas irrigated. Information on agricultural prices, human population according to sex, agricultural and non-agricultural pursuits, etc. (on the basis of 1951 census) has also been included. A number of misprints and discrepencies have marred the presentation of this review.

COTTON ATLAS OF INDIA (1957). Issued by Indian Central Cotton Committee, Bombay, Price Rs. 15/-.

Cotton is a textile fibre which is very useful to mankind. Its cultivation is widespread. It is one of the important agricultural commodities cultivated in India and has been grown in this country from ancient times. India was long famous for production of high quality cotton fabrics. A knowledge of the statistical data relating to the various aspects of cotton acreage, production and utilisation will, therefore, be helpful not only to students of agriculture, administrators and extension workers, but also to cultivators themselves and industrialists and consumers.

The Indian Central Cotton Committee has, therefore, done a distinct service to the country by producing a publication which contains factual data in respect of various aspects of cotton. Here, in this publication, data have been collected and put together either in the form of tabular statements, graphical illustrations or maps from which an interested person can gather information about various aspects of cotton acreage, production and utilization.

The book is divided into eight sections. Section I deals with data relating to cotton in various cotton producing countries and cotton consuming countries of the world. In Section II, the physical features of India have been depicted together with its soil characteristics, rainfall and communication. Section III contains maps, graphs, and tabular statements of data connected with cotton production in cotton-growing regions of India its cultivation, production and distribution. There are in this Section maps showing areas under long, medium and short staple cotton and also distribution of improved varieites. Maps in Section IV indicate centres of cotton research and cotton seed distribution. The data relating to the mill consumption of Indian and foreign cotton in India as well as its import and export are tabulated or otherwise illustrated in Section V. Section VI gives an idea of cotton production in the first Five Year Plan, while Section VII deals with cotton acreage and production in different States during 1955-56. Section VIII deals with miscellaneous statistics relating to India's share in the production of cotton textiles as compared to other countries in the world, world supply and distribution of cotton, area under cotton in India classified by varieties, production of cotton in India classified by varieties, production of cloth, etc. in India. The tabular statements grouped in this Section have not been collected together to form a separate compact part of the Atlas; they are interspersed among maps, tables and graphical illustrations grouped in the remaining other sections of the publication.

A great variety of useful data have been collected in this Cotton Atlas of India. The information scattered in many publications and also those unpublished have been put together in an attractive manner. The data thus collected together will certainly be found useful to a wide variety of interests. The publication is nicely printed on art paper and handsomely bound.

STATISTICAL YEAR BOOK (1957). Issued by United Nations, pp. 674, Price $ 6·50 (Paper bound).

The United Nations Statistical Year Book, 1957, provides a most comprehensive source of current data on world economic and social conditions. It contains statistical data in respect of 150 countries and territories, including USSR and all East European countries except Albania. Statistical data are given on various subjects such as population, manpower, agriculture, forestry, fishing, indices of industrial production, mining, construction, electricity, gas, consumption of food and industrial raw materials, transport and communications, internal and external trade, balance of payments, wages, prices, national income, finance, social statistics and education and culture.

A new chapter—International Economic Aid—has been included in this issue. The figures in this chapter relate to the period 1954-56 and show in U.S. dollars, grants and loans furnished to under-developed countries by individual governments and international governmental agencies and the total aid received related to population and per capita gross national product.

As a general rule, the data in the Year Book relate to the country specified within its present *de facto* boundaries. However, the homogeneity of some of the national

series shown in the tables has been appreciably affected by changes in territory, mainly as a result of World War II. Where territorial changes have significantly influenced the data, the position has been clarified through appropriate notes.

In respect of agricultural data, the Year Book gives index numbers of agricultural production: 1952-53 to 1955-56, and production of important individual agricultural crops like wheat, rye, maize, barley, oats, rice, groundnuts, cottonseed, linseed, soya-beans, potatoes, coffee, tea, tobacco, cotton, wool and livestock products. For important producing countries data are given, as far as possible, from 1934 or 1937 to 1956, while for less important producing countries data relates to pre-war average and the last three years. In regard to forests and fisheries, the data are given for total production for three or two pre-war years and for 1950 to 1956. Under the main head ' Consumption ', information has been given in regard to gross food supplies, net food supplies per capita, cotton, wool, rubber, energy, tin, steel and certain types of fertilisers.

Generally, the data utilised in this publication has been obtained directly from national statistical agencies or from official publications but in some cases the information has been furnished by specialized agencies and the latter type of data has been acknowledged in the publication.

The Year Book is a valuable compendium on world statistics relating to population, agriculture, trade, commerce, finance, educational and cultural position etc. In the face of great diversities of definitions etc. adopted by different countries of the world for various statistical data, encompassing of varied data in a single volume, represents a commendable efforts. H.L.C.

APPROACH TO FARMING IN SOUTHERN RHODESIA—L. T. Tracey.

This book has been written by a very successful English farmer in Southern Rhodesia. There is a strong practical touch in the writing. The experience gained by the author by extensive reading, has imparted the book a working shape and it can be adopted as a sure guide by young farmers in that country.

The subject matter of the text has been presented in 15 chapters, five appendices and a number of tables. The chapter on tillage describes the functions of various implements and how to correctly use them for opening up the land, clean cultivation and bringing the land into good tilth. The chapter on livestock deals with the composition of cattle feeds and lays emphasis on balanced feeding of stock. The succeeding chapters on beef herd, dairy herd, pigs, sheep, goats, and poultry give detailed directions on selection, breeding, management, feeding, treatment of diseases, buildings, etc., for the livestock. Maintenance of records of cattle and other stock is considered essential for success in the farming business. Directions have been given for disposal of stock and the by-products from them. Diagnosis of cattle diseases, which occur in that country, and first aid measures to relieve them have been given in some detail.

For successful production of maize, groundnut, beans, potatoes, sweet potatoes, wheat, cotton, green manures and fodder crops stress has been laid on soil management and Scientific crop husbandry including crop protection against pests and diseases. It is emphasised that cash crop and livestock farmers have to work their rotations into

a plan that will suit their system of farming. In Southern Rhodesia successful maize growing depends upon good soil management and use of hybrid corn seed more than on anything else. Trap cropsping is recommended by sowing Munga (Nyarti) to keep down witch weed.

The chapter on soil and water conservation contains useful hints viz. correct ploughing, rotational grazing, minimum of veld burning and proper farm planning and farming on the contour. There is also emphasis on maintaining Crumb Structure of the Soil, addition of fertilizers, mixed farming including grass leys as antierosion control measures. The growing and care of trees have been recommended to make a farm beautiful, to provide shade, building material and fuel. Practical directions have been given on preservation of timber. The subject of farm building contains information on building materials, their processing, planning of buildings and actual constructions. Peculiarities of native labour and how an English farmer can get the best of cut of them have been related in a readable fashion and to a purpose.

Taken all in all it is a useful publication for farmers who wish to launch upon stock raising and mixed farming in the English colonies in Africa.

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